The State Forests of Wisconsin

Continuous Forest Inventory
Baseline Report 2007 – 2011

Image: Pigeon Creek, Black River State Forest

Division of Forestry

WI Dept of Natural Resources

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DEPT. OF NATURAL RESOURCES

Abstract

The first annual inventory of Wisconsin's State Forests was completed in 2011 and reported over 466,000 acres of forest land on the ten properties. The total volume of growing stock was 615.5 million cubic feet or 1,353 cubic feet per timberland acre. Forest land on the State Forests is dominated by the white/red/jack pine forest type, which occupies about 22 percent of total timberland area. The aspen/birch forest type occupies an additional 21 percent with maple/beech/birch and oak/hickory accounting for about 15 percent each. . Because much of the land designated for the State Forests originated from abandoned agricultural land, a high percentage of forest land on these properties is dry and sandy.

Causes of mortality on the State Forests mirror the state as a whole: the majority due to insects and disease or the natural replacement of early successional species by more shade tolerant ones. More specific information on tree mortality as well as statistics on tree growth and removals will be available after the next annual inventory and re-measurement data becomes available.

This report includes additional information on forest and tree attributes, timber products, carbon and biomass, down woody debris, understory vegetation, soil properties and invasive species, forest health and disturbance, and statistics and quality assurance of data collection. Referral to statistics on the statewide forest resource are based on data from the USDA Forest Service's Forest Inventory and Analysis (FIA) program annual inventory system which is also administered in partnership with the Wisconsin Department of Natural Resources, Division of Forestry. The WisCFI generally follows the same methodology and techniques of FIA (see Data Sources and Techniques, pg 76).

Wisconsin Continuous Forest Inventory 2011

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Forward

There has always been a strong demand for timely, consistent, and reliable forest inventory and monitoring information for State Forests. Recently, the demand for timely and relevant information has been growing. Partners interested in State Forests want more recent information, covering a broader scope of forest attributes with more analysis and reporting capabilities. In response, the Wisconsin Department of Natural Resources implemented a State Forest Continuous Forest Inventory (WisCFI) program that will increase our capacity to collect, analyze and publish data on an annual basis for each State Forest individually and as a group (over 500,000 acres of forest and nonforest land).

The primary purpose of the Wisconsin CFI is to collect and report on the condition of the forest in a statistically sound manner on an annual basis for each State Forest. The information will be used to track the status and trends in forest extent, cover, growth, mortality, habitat, and overall health. The continuous forest inventory will provide unbiased, reliable information at the property level with the ability to incorporate regional trends. The inventory will assist in planning, management and monitoring.

Inventory goals:

- Provide information on the condition and health of the forest and track changes over time.
- Integrate effectively data, methods and tools in the planning and decision making processes.
- Develop and maintain data input models and methods for forestry analysis and planning.
- Develop up-to-date and easy-to-use information products and services for property managers and our public and partners.

The DNR is directed to manage the State Forests using the principles of sustainable forestry in order to assure that they can provide a full range of benefits for present and future generations as per the 1996 revisions to Wis. Stats. 28.04. In order to lay the groundwork for this management strategy, the department completed a series of forest assessments that established our current best available information on the condition of these forests. These assessments combined with the public input received through the development of the State Forest master plans, have identified a range of ecological criteria and variables that need to be inventoried and monitored in order to assure the department is meeting the goals of sustainable forestry in the management of the State Forests. An intensive continuous inventory of permanent plots will provide scientifically supportable, accurate, detailed, and up to date information on the sustainability of forest management practices on State Forest lands. Continuous inventory and monitoring data will be used to develop policy to assure the sustainable management of State Forest lands.

A number of groups rely on the WisCFI for critical information about the sustainability of Wisconsin's State Forests, including:

- State Forest policy makers
- Department of Natural Resources foresters
- Private consulting foresters
- Forest industry members
- Environmental organizations
- Scientists
- Journalists
- General public

WisCFI data play an important part in the efforts of these groups to:

- Formulate sound forest policy and assess the sustainability of current and past policies.

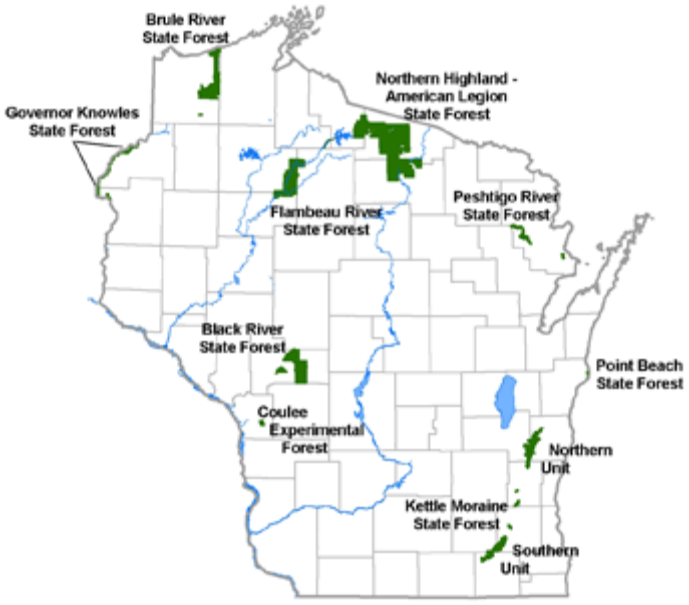

Figure 1.-Wisconsin's State Forests.

- Develop improved forest management plans and evaluate the effects of previous management practices on forest lands.
- Conduct scientific investigations that involve changes in forest ecosystems over time.
- Keep the public informed about the health and sustainability of Wisconsin's forests.

The inventory covers 10 properties designated as State Forests (Figure 1). The State Forests are generally located in the northern half of the state. The total acreage for the ten State Forests is 518,650 acres, the largest property being 233,000 acres and the smallest at 2,900 acres.

Table 1. Total area of all land (including nonforest land) on State Forests in Wisconsin, 2006.

State forest property	**Acres***
Black River State Forest	67,801
Brule River State Forest	40,332
Coulee Experimental Forest	2,944
Flambeau River State Forest	89,764
Governor Knowles State Forest	19,845
Northern Highland American Legion State Forest	232,876
Kettle Moraine State Forest - NU	29,600
Kettle Moraine State Forest - SU	20,677
Peshtigo River State Forest	11,926
Point Beach State Forest	2,884
TOTAL	518,650

* Acres based on 2006 property acres used for determining plot selection. WisCFI acreage data in the report are slightly different due to annual changes, estimation and rounding.

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HIGHLIGHTS

- Whereas less than half of the land in the state as a whole is forested, almost 90 percent of State Forest land is forested.
- The vast majority (97.5%) of forest land in the State Forests is productive timberland
- The percentage of forest land in the lowest productivity class is higher in the State Forests than in the rest of the state.
- The three major forest type groups on the State Forests are pines, aspen/birch and maple/beech/ birch, all economically valuable types.
- The State Forests contain a larger percentage of pines than the rest of the state and produce 6.3% of all pine biomass.
- Volumes of softwood growing stock are very high on the State Forests, particularly red and white pine, two economically important species.
- Ten percent of aspen acreage on Wisconsin's State Forests is greater than 60 years old and only 5% of aspen acreage is <10 years old.
- Acreage of hemlock continues to be scarce as a component of Wisconsin's State Forests.
- The State Forests contain more than 45.7 million tons of carbon, mostly in soil organic matter.
- Snag density on Wisconsin State Forest land averages 18 standing dead trees per acre, providing valuable structure and habitat.
- Aspen, paper birch and jack pine have higher percentages of standing dead trees than most other species on our State Forests. Birch and aspen are early successional species which are expected to decline as natural succession takes place. Jack pine is a fire-dependent species which is decreasing in number, both due to mortality caused by jack pine budworm and decreased natural and artificial regeneration.
- Both average crown dieback and crown transparency for trees growing on the State Forests are lower than for trees growing in the rest of the state. This indicates that State Forest trees are healthier than average.
- Since only 1.3% of forested land on the State Forests is bare soil, erosion should not be a major concern. This will help minimize loss of soil productivity as well as degradation of aquatic ecosystems.

- About 8% of forest land soil on the State Forests is affected by compaction.
- Most of the State Forests in northern Wisconsin are, as yet, fairly free of invasive plant species as they are located far from the major urban centers.
- The coverage of invasive species is highest in the State Forests which are closest to major urban areas and is increasing rapidly. Almost a third of the acreage of the Kettle Moraine State Forest - Southern Unit and 5.5% of the Kettle Moraine State Forest -Northern Unit have a high coverage of invasive species. These species can hinder regeneration of native plants and trees.
- Due to a large percentage of sandy soils on the State Forests, the diversity of understory vegetation tends to be lower than in the rest of the state.
- Apart from active forest management, only about 3 percent of State Forest acres were disturbed from 2007 to 2011. Half of this was due to weather-related events.
- Although the percent of forest land disturbed by causes other than harvest was small, insects and disease accounted for almost a third of this. In forests such as the Kettle Moraine State Forest NU and the Peshtigo, insects and disease caused 50% and 100%, respectively, of all disturbed acres. Wind which made up over 25% of total disturbed acreage, accounted for 75% of acres in the Flambeau River State Forest.
- Emerald ash borer has not yet been observed on any of the State Forest lands and ash is not a prominent species on most of the properties. However, on the Kettle Moraine State Forest- NU, ash represents one out of every four growing stock trees. On Governor Knowles State Forest, 12% of all trees are ash and on the Flambeau State Forest, 9% of growing stock trees are ash. It is considered likely that EAB will arrive on all properties with ash trees.
- Because sandy soils predominate on the State Forests, trees may be more susceptible to insects and diseases, especially during periods of prolonged drought. Diseases of red pine and oaks, two prominent specie groups may be especially problematic on dry, sandy soils.
- Very old forest and stands meeting the state's definition of old growth are extremely scarce on State Forest land compared to the rest of the state.
- Compared to old-growth forests, the State Forests have a much lower quantity of highly decayed coarse woody debris (CWD). The State Forests not only lack large (>23 inches) pieces of CWD but overall have lower volumes of CWD compared to other managed forest.

BACKGROUND

A Beginner's Guide to the Wisconsin Continuous Forest Inventory

In general, the WisCFI follows the procedures and definitions of the USDA Forest Service, Forest Inventory and Analysis (FIA) program, a data collection system based on plot networks which are re-measured at 5-year intervals (Perry et al 2012). FIA collects, analyzes and reports information on the status and trends of Wisconsin's forests: how much forest exists, where it exists, who owns it, and how it is changing. FIA also reports on how the trees and other forest vegetation are growing and how much has died or has been removed in recent years. This information can be used in many ways, including assessing the sustainability of forest management practices, evaluating the health condition and potential future risks to our forests as well as projecting what our forests might look like in 10 to 50 years. WisCFI terms used in this report as well as references to characteristics of forest land statewide are based on FIA methods and analysis.

What is a tree?

WisCFI defines a tree as any perennial woody plant species that can attain a height of 15 feet at maturity.

What is a forest?

WisCFI defines forest land as land that is at least 10 percent stocked by trees of any size or formerly having had such tree cover and not currently developed for non-forest use. The area with trees must be at least 1 acre in size, and roadside, streamside, and shelterbelt strips must be at least 120 feet wide to qualify as forest land. Forest types are defined in the Appendix.

What is the difference between timberland and other forest land?

From a WisCFI perspective, there are two types of forest land: timberland and other forest land. On Wisconsin State Forest lands, 97.5 percent of the forest land is timberland.

- Timberland is forest land that meets the minimum productivity requirement of 20 cubic feet per acre per year at its peak.
- Other forest land is commonly found on low-lying sites with poor soils where the forest is incapable of producing 20 cubic feet per acre per year at its peak.

We can report volume on both forest land and timberland since trees were measured on all forest land. Because we have just completed the first full 5-year cycle of the WisCFI these annual plots have not been re-measured yet. As a result, we are unable to report growth, removals and mortality on State Forest

lands. In 2012, the 2007 plots were re-measured and change parameters will be available at the end of the inventory panel.

Where are Wisconsin's State Forests and how many trees are growing on them?

Wisconsin's larger State Forests are primarily located in the northern part of the state with the exception of the Northern and Southern Units of the Kettle Moraine State Forest in southeastern Wisconsin, the Black River State Forest and the Coulee Experimental Forest in the west central region. There are approximately 322 million trees on Wisconsin's State Forest land that are at least 1 inch in diameter as measured at 4.5 feet above the ground.

How do we estimate a tree's volume?

FIA has typically expressed volumes in cubic-feet. But, in Wisconsin, wood is also commonly measured in cords (a stack of logs 8 feet long 4 feet wide and 4 feet high). A cord has approximately 79 cubic feet of solid wood and 49 cubic-feet of bark and air.

Volume is estimated in this report by using the method used by the FIA program. Several hundred cut trees were measured by taking detailed diameter measurements along their lengths to accurately determine their volumes (Hahn 1984). Regression lines were then fit to these data by species group. Using these regression equations, we can produce individual-tree volume estimates based on species, diameter, and tree site index.

The same method was used to determine sawtimber volumes. FIA reports sawtimber volumes in ¼-inch International board foot scale. Conversion factors for converting to Scribner board foot scale are also available (Smith 1991).

How much does a tree weigh?

The U.S. Forest Service's Forest Products Laboratory and others developed specific gravity estimates for a number of tree species (Miles and Smith 2009). These specific gravities were then applied to tree volume estimates to derive estimates of merchantable tree biomass (the weight of the bole). To estimate live biomass, we have to add in the stump (Raile 1982) and limbs and bark (Heath et al. 2009). We do not currently report the live biomass of roots or foliage.

Forest inventories report biomass as green or oven-dry weight. Green weight is the weight of a freshly cut tree; oven-dry weight is the weight of a tree with 0 percent moisture content. On average, 1 ton of oven-dry biomass is roughly equal to 2 tons of green biomass.

How do we estimate all the forest carbon pools?

For this report carbon in standing trees was not measured, nor was carbon in belowground pools. It is assumed that half the biomass in standing live/dead trees consists of carbon. The remaining carbon pools (e.g., soil, understory vegetation, belowground biomass) are modeled based on stand/site characteristics (e.g., stand age and forest type).

A word of caution on suitability and availability…

The master plan for each State Forest guides harvest levels and the suitability and availability of timber production on State Forests. This report does not attempt to identify which lands are suitable or available for timber harvesting. The classification of land as timberland does not necessarily mean it is suitable or available for timber production.

FOREST FEATURES

Land Use

Background

The majority of the State Forests in Wisconsin were officially established by the legislature in the late 1920s and 30s. Many acres were acquired earlier and managed as soon as the Forestry Commission and the first State Forester were appointed in 1904. E.M. Griffith felt that "the main reason for establishing

Peshtigo River State Forest (Wisconsin Dept of Tourism, http://dnr.wi.gov/topic/parks/name/peshtigoRiver/)

forest reserves in Wisconsin was to preserve the stream flow in the important rivers… where the greatest rivers of the state rise." Between 1904 and 1906, the first forest reserve, later to be called the Northern Highland State Forest, was created. Five State Forests were created in the 1930s. The youngest forests, the Black River, Governor Knowles, and the Peshtigo River, were initiated in 1957, 1970, and 2001 respectively. Today, State Forests total over 500,000 acres of forest and non-forested land on ten State Forests.

Much of the public land in northern Wisconsin was acquired as a result of farm tax delinquency during the 1930's depression years. Tax delinquency was a result of hard economic times and difficult growing conditions in northern Wisconsin. The land was generally not very productive for agricultural use due to poor soils and a shorter growing season than southern Wisconsin. As a result, public forest lands are thought to be less productive in general than other land in the state.

What we found

Almost 90 percent (466,824 acres) of all 518,649 acres of State Forests in Wisconsin was forest land in 2011. Of the remaining 10 percent, 7 percent (37,546 acres) was non-forest land and 3 percent (14,279 acres) was covered with open surface water. The Flambeau River State Forest in northwestern Wisconsin is the most heavily forested State Forest property in the state (95 percent), while the Kettle Moraine State Forest – Southern Unit in southeastern Wisconsin is the least forested (70 percent) (Table 2).

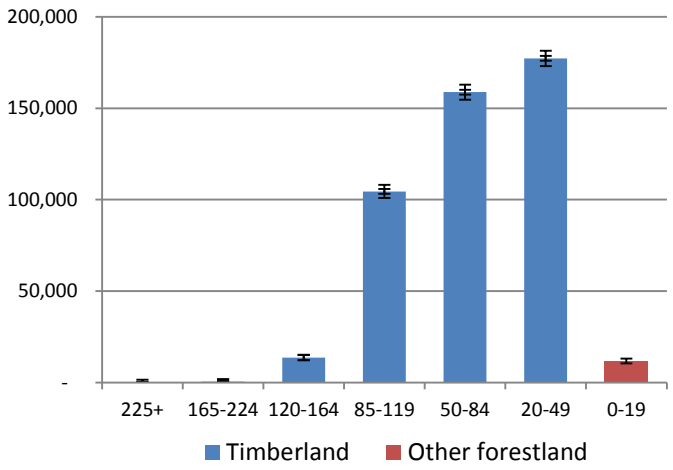


Figure 2. Area of forest land (acres) on all State Forests by land use and productivity class, Wisconsin, 2011.

Table 2. Acreage of all State Forests by major land use, Wisconsin, 2011.

State Forest Property	Forest land	Nonforest	Noncensus water	Census water	Total
Northern Highland American Legion	212,621	13,304	2,040	4,911	232,876
Black River	60,650	5,583	410	1,158	67,801
Brule River	36,995	2,563	436	337	40,332
Coulee Experimental Forest	2,513	432	-	-	2,944
Flambeau River	85,530	3,190	257	787	89,764
Governor Knowles	18,459	1,220	166	-	19,845
Kettle Moraine – NU	24,430	4,661	329	179	29,600
Kettle Moraine – SU	14,388	6,121	-	168	20,677
Peshtigo River	8,524	303	628	2,472	11,926
Point Beach	2,714	170	-	-	2,884
All properties	**466,824**	**37,546**	**4,267**	**10,012**	**518,649**

While only 1% of non-reserved forest land statewide is classified as low productivity land (Perry et al 2012), the percentage climbs to 2.5% on State Forests (Figure 2).

The percentage of low productivity (not capable of producing more than 49 cubic feet of wood/acre/year) forest land is higher on the State Forests than in the rest of the state. Forty percent of State Forest forest land has low productive capability. Of all forest land statewide, 32 percent is classified as having low productive capability (Perry et al 2012). The percentage of low productivity forest lands is 32 percent on the national forests and 34 percent on the county forests (Figure 3).

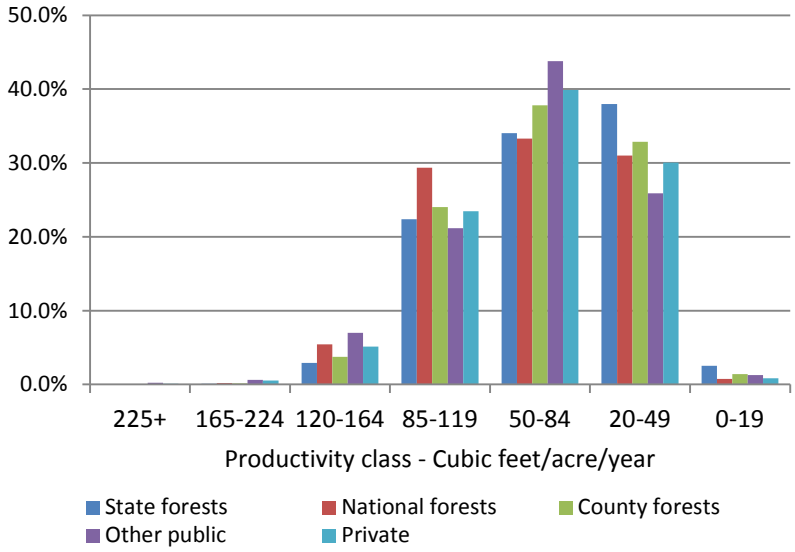


Figure 3. Percent of each ownerships total forest land acreage by productivity class, Wisconsin, 2011.

Of all of the State Forests in the state the Governor Knowles State Forest has the highest percentage of low productivity forest land (66 percent) while the Coulee Experimental State Forest has the least low productivity forest land (28 percent) (Table 3).

Table 3. Percent of each State Forest acreage by productivity class, Wisconsin, 2011.

Site productivity (cft/acre/yr)	NH AL	Black River	Brule River	Coulee Exper	Flambeau River	Governor Knowles	Kettle Moraine – NU	Kettle Moraine – SU	Peshtigo River	Point Beach	All State Forests
225+	0	0	0	0	0	0	0	0	0	0	0
165-224	0	0	0	7	0	0	0	0	0	0	0
120-164	2	3	3	10	3	0	8	5	6	0	3
85-119	25	19	31	**34**	20	6	19	23	21	0	22
50-84	**37**	29	**39**	21	29	28	30	30	**42**	44	34
20-49	34	**45**	23	28	**45**	**61**	**40**	**39**	31	**47**	**38**
0-19	2	4	4	0	2	5	3	3	0	9	3
Total	100	100	100	100	100	100	100	100	100	100	100

What this means

As would be expected, State Forests are more highly forested than the rest of the state. Of the 35 million acres of land and surface water in Wisconsin, only 46 percent is forested compared with almost 90 percent on State Forest properties. Forest land on State Forests in Wisconsin is less productive than all other forest land ownerships and Governor Knowles State Forest is the least productive.

Forest Area

Background

The vast majority of land (90%) on the State Forests of Wisconsin is forested and 97% of this is considered timberland. The forest types on these properties represent a way of categorizing land by dominant species and is often reflective of habitat and site quality. Because the State Forests have a higher percentage of sandy soils, the dominant forest types are somewhat different than in the rest of the state.

Red pine plantation (Steve Katovich, USDA Forest Service, Bugwood.org)

What we found

The white/red/jack pine forest type group accounts for about 22% of all timberland on the State Forests. About 80% of these pine forests are on sandy soils with a habitat type that is categorized as very dry to dry. The aspen/birch type accounts for another 21% of timberland on the State Forests. The maple/beech/birch type accounts for 18%of all acreage and the oak/hickory type for 14%. Over half of the acreage of these three important types are on sandy soils.

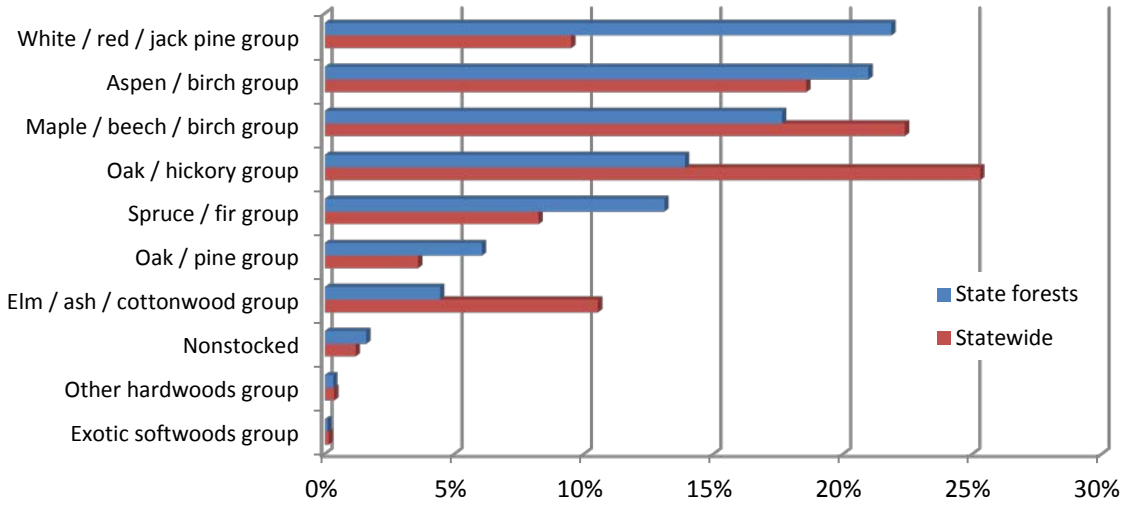


Figure 4. Percent of all timberland acreage by forest type group: State Forests compared to statewide. Exotic softwoods include Scotch pine and Norway spruce.

The two State Forests which are predominantly pine are Black River State Forest and Point Beach State Forest. The Flambeau River State Forest is the only property on which maple/beech/birch is the predominant type and the Brule River State Forest is the only forest on which aspen/birch is the dominant

Pigeon Creek in the Black River State Forest (DNR website, http://dnr.wi.gov/topic/StateForests/blackRiver/)

type. Oak/hickory dominates on several State Forests, including the Coulee Experimental Forest, both units of the Kettle Moraine State Forest, and Governor Knowles State Forest.

The largest differences between the State Forests and statewide timberland (Figure 4) is the higher percentage of pine (22% compared to 10% statewide) and the lower percentage of oak/hickory (14% compared to 25% statewide) on the State Forests (Perry et al 2012). This is probably due to the fact that the majority of State Forest land is located in the northern part of the state and oak/hickory is largely a central and southern type.

What this means

The pines and aspen are very important pulpwood species in Wisconsin. Maple, aspen, and pine accounted for almost 70 percent of the total industrial roundwood harvest statewide in 2008 (Perry et al 2012). The pine, aspen/birch and maple/beech/birch forest types make up over 60% of the acreage of Wisconsin's State Forests. The fact that these types are located mainly on sandy soils on the State Forests may make these stands especially vulnerable to seasonal drought and forest health issues.

Tree Species Composition

Background

Forest composition is dynamic, changing over time both within stands of trees and across forested landscapes. Forest change often is slow but sometimes it can be abrupt and drastic. Important factors that influence forest composition include climate and soil; forest disturbances such as fire, storms, insects and diseases, as well as tree cutting, regenerative ability of nearby tree species and other forest management decisions. The composition of trees within a forest can influence the composition of other plants, soil makeup and animal habitat and, in turn, may be influenced by them.

Northern hardwood stand (Steve Katovich,USDAFS, Bugwood.org)

What we found

Compared to the rest of state, the State Forests contain a higher percentage of drought tolerant species such as Eastern white pine, jack

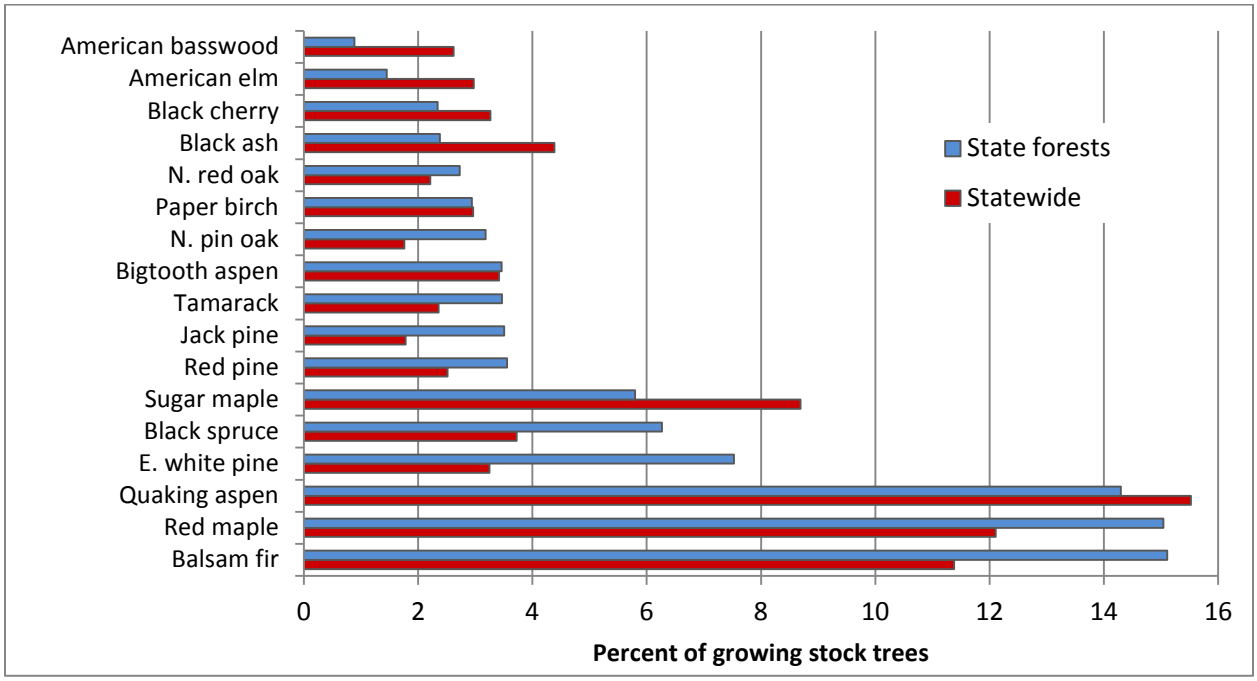


Figure 5. The percentage of growing stock trees by species on the State Forests and statewide.

pine, red pine and northern pin oak. They also contain more tamarack and black spruce which are typical of wetter sites (Figure 5). The prevalence of these species may be explained by the fact that the land that

was acquired for the State Forests was farmland that was unproductive. Much of this land was either too dry or too wet to support agriculture.

The vast majority of growing stock trees are less than ten inches. However, certain species on the State

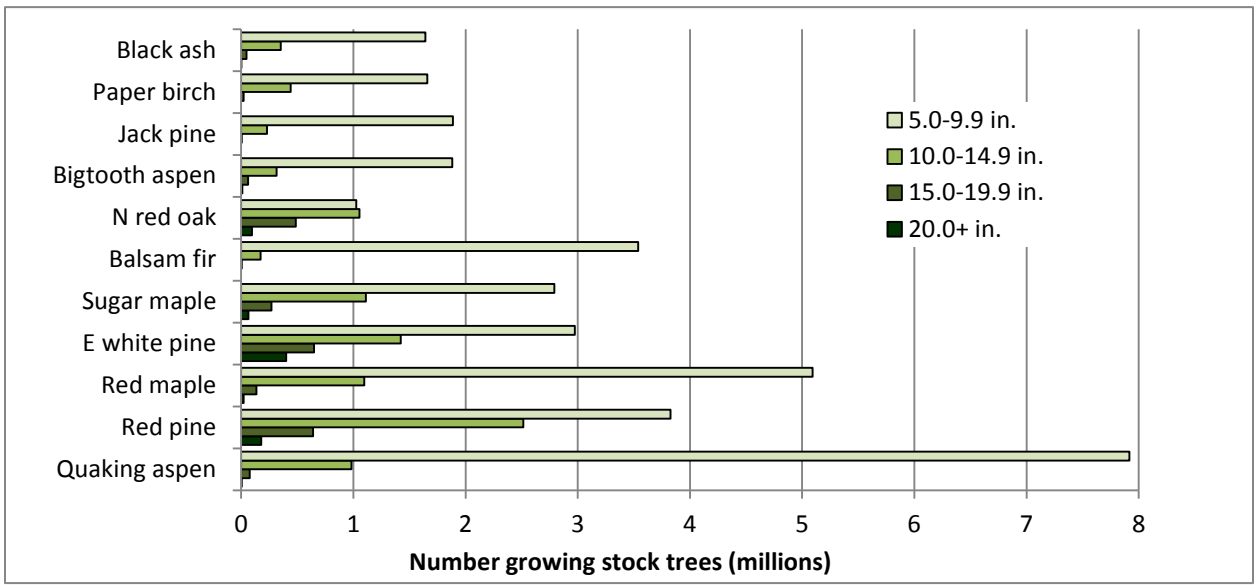


Figure 6. The number of growing stock trees (millions) by five-inch diameter size class.

Forests have more large trees than other species. The species with the highest number of large trees (over 20 inches dbh) are Eastern white pine, red pine, sugar maple, and northern red oak (Figure 6). The species with the largest numbers of small trees are quaking aspen, red maple and balsam fir.

What this means

The State Forests have a high percentage of pines. The fact that many of these trees are growing on sandy soils makes them more susceptible to disease and pest problems, including jack pine budworm, Annosum root disease, red pine pocket decline and Armillaria. Many of the pines are over 15 inches in diameter which increases their value as sawtimber.

Forest Structure

Background

Forest trees and stands regenerate, grow, mature, and senesce (the process of deterioration leading to death). Some tree species, such as aspen, grow rapidly and typically live less than a century; whereas others, such as hemlock, grow more slowly and can live for several centuries. Younger forests tend to grow faster. As stands become older, trees become fewer and larger. Old-growth forests typically contain trees of many different ages and sizes, including some old, senescent individuals.

Eastern hemlock (Vern Wilkins, www.bugword.org)

In Wisconsin, most forests were cutover and many acres burned in the late 1800s and early 1900s. Following the cutover, many areas were temporarily farmed and pastured. Most current forests originated on open land and developed into even-aged stands where trees are about the same age. Some of these stands, particularly those dominated by shorter lived and faster growing tree species, have been harvested for timber and regenerated. Stands continue to grow and age, and, in general, trees in Wisconsin State Forests are harvested before they approach senescence. However, the development and maintenance of old-growth and old forest structural characteristics is a management goal for some stands.

What we found

The 2011 Wisconsin Continuous Forest Inventory (WisCFI) shows that about 53% of forest land acres on Wisconsin State Forests are between 11 and 60 years old originating in the mid to late 1900's (Figure 7). Approximately 34% of forest land acres on the State Forests are 61 to 100 years old, originating in the early to mid-1900s. Eight percent of forest land

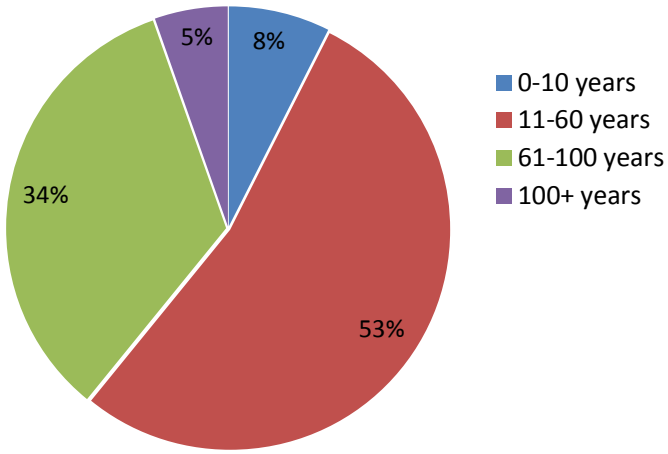


Figure 7. The percent distribution of age classes for State Forests.

acres in Wisconsin's State Forests are less than 11 years old and 5% are more than 100 years old. This indicates that most of the stands on State Forest land in Wisconsin are in the stand initiation and stem exclusion stage of structural development.

The general definition for old-growth, as developed by the Wisconsin DNR is a forest that is "relatively old and relatively undisturbed by humans." WisCFI data indicates that around 5 percent or approximately 25,000 acres of State Forest land has a stand age of greater than 100 years (Table 4).

Aspen is the most common forest type in Wisconsin's State Forest comprising about 74,000 acres or

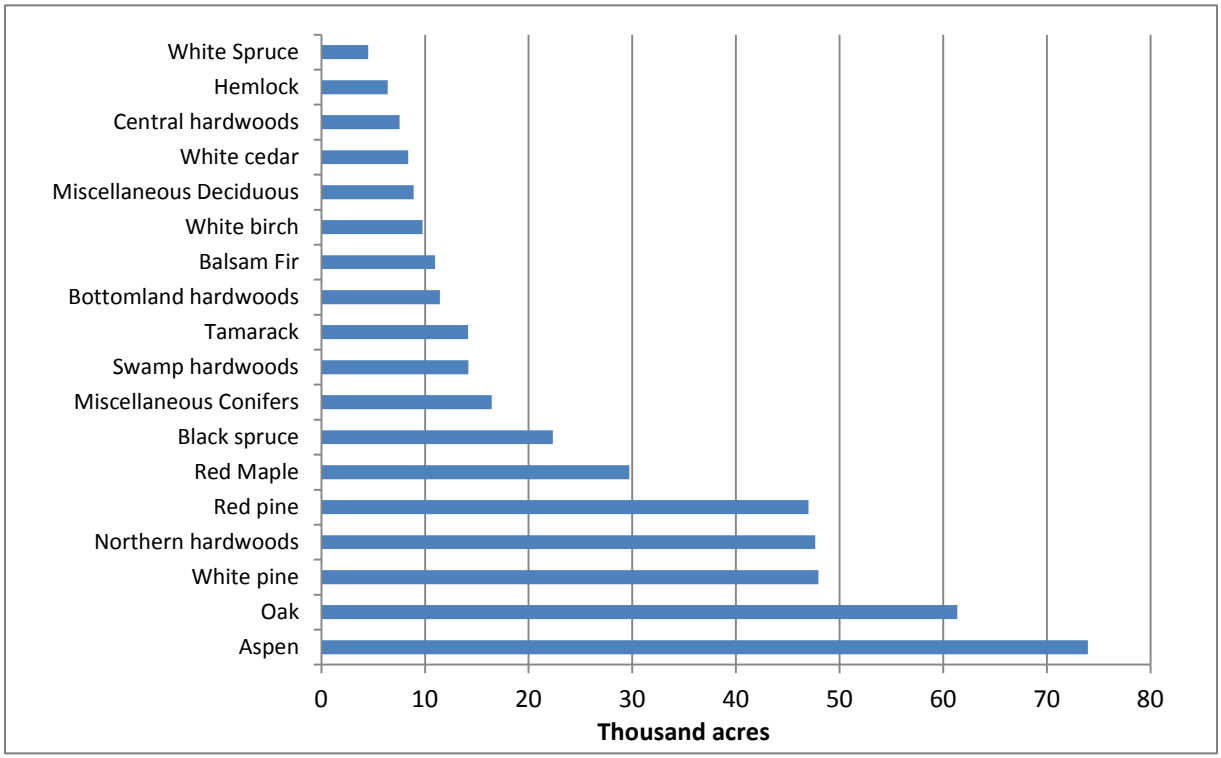


Figure 8. Acreage of WisCFI forest types in Wisconsin State Forests.

about 16% of State Forest land (Figure 8). Other common forest types include oak (61,369 acres; 13%), white pine (48,000 acres; 10%), red pine (47,000 acres; 10%), and northern hardwoods (47,650 acres; 10%). Hemlock and white spruce are among the least common forest types on State Forest land.

In general, snag density in Wisconsin's State Forests is approximately 18 standing dead trees per acre (>5" dbh). The white cedar and white birch forest types have the highest snag densities at 34.5 SDT/acre each. The balsam fir (29.5), aspen (29.1) and white spruce (25.6) forest types also have comparatively

Table 4. Acres of Wisconsin State Forest land by age class and WisCFI forest type.

Forest type	0-20 yrs	21-40 yrs	41-60 yrs	61-80 yrs	81-100 yrs	100+ yrs	All age classes
Aspen	9,777	32,669	24,257	4,906	1,851	480	73,939
Balsam Fir	2,324	3,038	3,381	1,314	671	248	10,976
Black spruce	3,225	4,159	5,628	6,844	1,799	668	22,322
Bottomland hdwds	1,256	3,708	3,249	1,666	1,067	490	11,435
Central hdwds	847	2,359	2,106	1,133	926	168	7,538
Hemlock	333	328	711	1,894	1,573	1,546	6,385
Misc Conifers	4,025	5,374	5,367	1,577	84	-	16,428
Misc Deciduous	3,674	2,672	1,676	558	333	-	8,914
Northern hdwds	915	3,153	7,405	20,210	11,572	4,389	47,645
Oak	7,999	7,109	9,282	15,462	16,189	5,328	61,369
Red Maple	3,950	4,051	8,413	7,891	3,971	1,430	29,705
Red pine	4,384	8,975	16,730	7,883	7,058	1,965	46,995
Swamp hdwds	187	677	1,436	5,199	4,265	2,411	14,174
Tamarack	1,002	3,062	3,172	4,313	2,016	580	14,144
White birch	1,524	1,386	3,258	2,613	640	334	9,756
White cedar	131	454	1,838	803	2,625	2,511	8,361
White pine	6,199	9,704	14,360	7,284	8,088	2,338	47,973
White Spruce	375	846	2,312	585	319	83	4,520
Total	**71,712**	**97,010**	**115,394**	**92,339**	**65,207**	**25,162**	**466,824**

high snag densities. The tamarack (7.2), black spruce (7.9), and red pine (9.0) forest types have the lowest snag densities among WisCFI forest types (Figure 9; Table 5).

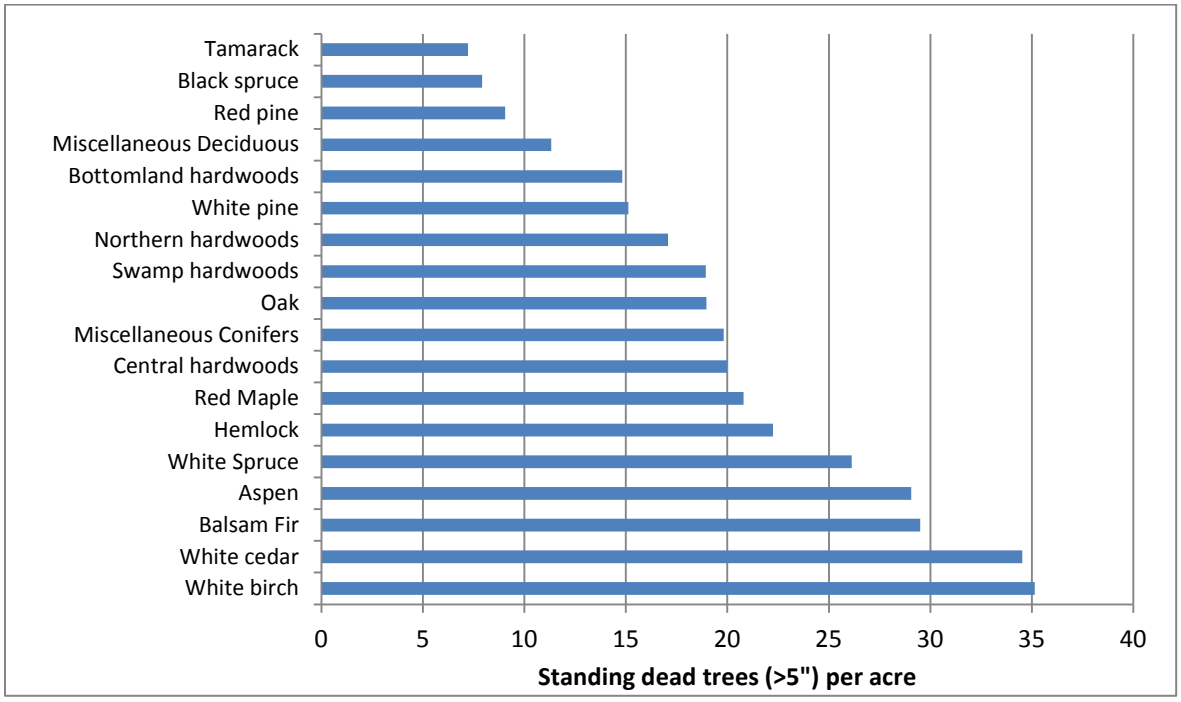


Figure 9. Standing dead trees per acre by WisCFI forest type.

Table 5. Number of standing dead trees 5 inches+ dbh on forest land by forest type and stand age class.

Forest type	0-20 yrs	21-40 yrs	41-60 yrs	61-80 yrs	81-100 yrs	100+ yrs	All age classes
Aspen	62,257	899,733	913,349	193,990	62,988	15,992	2,148,309
Balsam Fir	104,649	46,157	106,463	26,111	30,419	9,964	323,763
Black spruce	16,095	18,107	56,255	74,194	5,998	6,051	176,699
Bottomland hdwds	6,057	62,309	46,317	15,969	38,789	-	169,441
Central hdwds	13,950	32,183	43,948	37,986	22,476	-	150,543
Hemlock	1,993	3,986	13,950	69,997	26,040	26,116	142,081
Misc Conifers	21,943	60,206	184,819	58,604	-	-	325,572
Misc Deciduous	18,105	19,993	56,719	6,065	-	-	100,882
Northern hdwds	8,000	66,174	144,338	330,146	186,853	78,186	813,696
Oak	50,237	104,597	255,443	391,039	272,130	90,813	1,164,259
Red Maple	30,040	64,304	198,696	196,879	105,948	21,997	617,864
Red pine	4,024	52,316	179,592	54,417	114,652	20,119	425,120
Swamp hdwds	6,088	12,091	22,173	131,447	70,556	25,997	268,351
Tamarack	4,005	10,067	18,000	38,180	18,029	13,950	102,231
White birch	34,219	34,350	139,137	108,709	16,392	10,059	342,867
White cedar	4,024	14,083	22,254	40,361	124,944	82,976	288,641
White pine	40,154	111,928	248,205	120,249	162,450	42,269	725,254
White Spruce	8,048	5,979	73,939	24,066	6,036	-	118,067
Total	**519,960**	**1,618,560**	**2,727,621**	**1,918,407**	**1,264,698**	**444,490**	**8,493,736**

What this means

Most of Wisconsin's State Forest stands are even-aged and relatively young. Most stands are 10- 60 years old and most trees are generally smaller in diameter. These age and size characteristics can be attributed to several factors:

- Relatively little time has passed since the cutover of forests and the abandonment of farms.
- Some species on some sites don't normally reach large sizes or advanced ages.

Harvesting imposes an upper age limit in managed forests. Forests greater than 100 years of age are scarce on the State Forests.

Tree Mortality

Background

Mortality can be caused by insects, disease, adverse weather, succession, competition, fire, old age, or human or animal activity, and is often the result of a combination of these factors. Tree volume lost as a result of land clearing or harvesting is not included in mortality estimates. Mortality is typically recorded on WisCFI plots by re-measuring trees every five years. Since this has not yet been done on the Continuous Forest Inventory plots, mortality was estimated using the percentage of all trees that are dead but still standing[1].

What we found

The species with the highest percentages of standing dead trees on the State Forests (Table 6) are paper

Table 6 . Ratio of standing dead trees to all growing stock trees by species and State Forest property.

Species	Black River	Brule River	Flambeau River	Governor Knowles	Kettle Moraine NU	Kettle Moraine SU	Peshtigo River	NHAL	All properties*
Paper birch	4%	6%	8%	5%	5%		14%	13%	11%
N. white-cedar		6%	54%	4%	5%		2%	13%	8%
Yellow birch	3%	500%	8%	9%	1%			11%	7%
Jack pine	7%	14%		5%			47%	4%	6%
E white pine			20%				10%	2%	5%
White spruce		4%	8%	10%				2%	5%
American elm	1%		4%	11%	9%	9%	7%		5%
Quaking aspen	4%	4%	9%	3%	5%	9%	9%	4%	5%
Bur oak	7%			3%	2%	21%			4%
Black oak	2%	2000%				13%			4%
N. pin oak	1%	6%		2%		5%	20%	2%	3%
Bigtooth aspen	4%	4%	10%	3%	5%	8%	5%	2%	3%
Balsam fir		5%	4%	23%			6%	2%	2%
N. red oak	9%	16%	4%	14%	9%	3%	9%	1%	2%
E. hemlock	1%	6%	30%	4%	20%	3%	1%	3%	2%
A. basswood		4%	2%	2%	3%			5%	2%
Tamarack	0%	7%	1%	4%	208%		2%	1%	2%
Red pine	1%	1%	5%	1%	4%	10%	2%	2%	2%
Sugar maple		1%	2%	1%	0%			1%	1%
Black ash		1%	2%	1%				1%	1%
Green ash			1%	2%	1%		14%		1%
Red maple	0%	0%	2%	1%	5%		0%	1%	1%
Black spruce	2%	4%	1%	4%				1%	1%
Black cherry		1%	2%		3%	2%		0%	1%
White ash		6%	1%		1%			2%	1%
All species	**1.9%**	**3.9%**	**3.9%**	**2.9%**	**4.4%**	**5.1%**	**4.5%**	**2.4%**	**2.8%**

* The Coulee Experimental Forest and Point Beach State Forest were omitted due to high sampling error.

[1] Using the statewide FIA data for 2011 (Perry et al 2012), the percentage of standing dead trees for a particular species correlates well with the mortality ratio (Pearson's correlation coefficient = 0.85, $p<0.000$) for that species.

birch, yellow birch, jack pine, American elm, quaking aspen, and northern pin oak in descending order. The northern and southern units of the Kettle Moraine State Forests showed the highest percentages overall, mainly due to high mortality of oaks, red pine and American elm. The Black River State Forest had the lowest percentage of standing dead trees, followed by the Northern Highland American Legion State Forest.

What this means

As we would expect, aspen and birch are early successional species which are being replaced by more shade tolerant species. Jack pine and American elm have suffered high mortality due to pest problems, specifically jack pine budworm and Dutch elm disease. Northern pin oak is highly susceptible to oak wilt and two-lined chestnut borer, especially on sandy soils and in areas that have experienced significant drought.

Forest Biomass

Background

Understanding the composition of a forest is key to making informed decisions on how certain stands can be managed for a variety of uses. There is renewed and growing interest in developing ways to harness energy in the form of biofuel from our forests.

What we found

It is estimated that total live-tree biomass on Wisconsin's State Forests is nearly 10.5 million dry tons. Softwoods account for nearly 35 percent of this material while hardwoods comprise 65 percent. There is a much higher percentage of red and white pine biomass on the State Forests, 26% compared to 11%

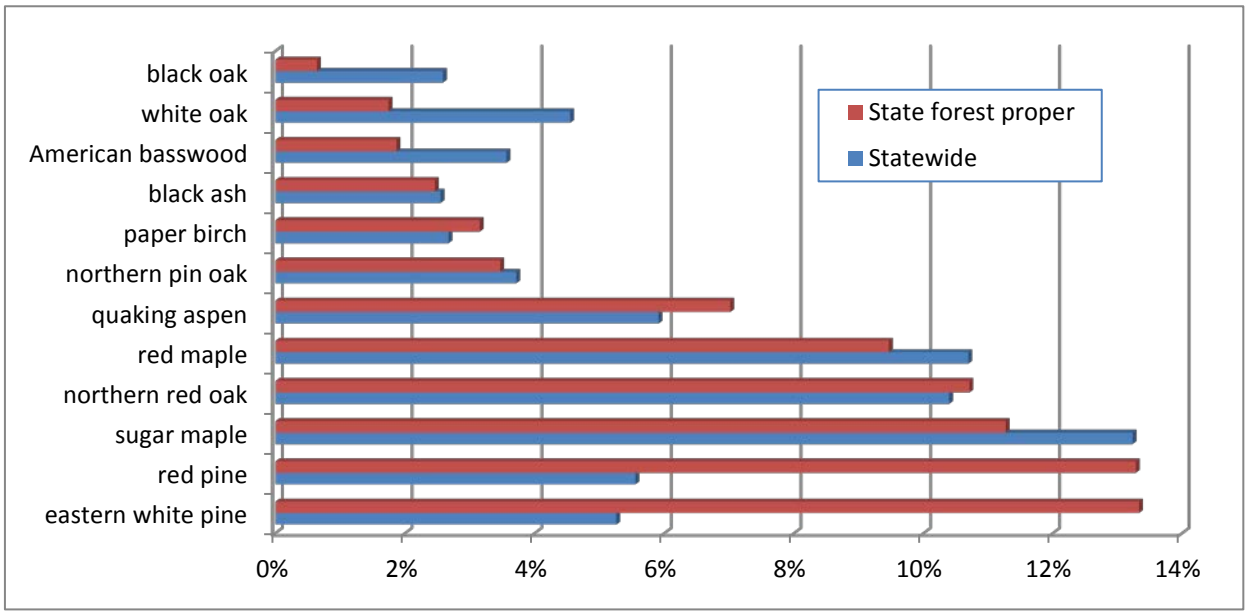


Figure 10. A comparison of the percent contribution by species to biomass between State Forests and statewide timberland.

statewide (Figure 10, Perry et al 2012). The State Forests have significantly lower biomass in sugar maple, white oak and black oak compared to the rest of the state.

It is useful to understand an estimate of all live merchantable biomass on State Forests. Table 7 shows this distribution by forest type on State Forests compared to private timberland. The state properties only contain about 2.5% of all biomass but 6.3% of all pine biomass.

Table 7. Distribution of all merchantable live-tree biomass by forest type on State Forests and private lands statewide.

	Live-Tree Biomass (dry tons)	
Forest Type	**State Forests**	**Private lands statewide***
White / red / jack pine group	2,867,722	28,722,954
Maple / beech / birch group	2,584,047	78,807,015
Oak / hickory group	1,963,754	115,866,662
Aspen / birch group	1,441,008	28,646,244
Oak / pine group	592,920	10,578,831
Spruce / fir group	580,521	11,736,608
Elm / ash / cottonwood group	425,098	26,649,059
Minor groups	29,533	948,330
Total	**10,484,603**	**301,955,703**

*Perry et al 2012

What this means

New technology and innovative processes for capturing energy from wood and wood residues is positioning biomass to become an increasingly attractive alternative to traditional sources of energy. Overall, total forest biomass in Wisconsin is increasing. While most forest biomass can be found in trees on private land, our State Forests boast their fair share.

There is a higher percentage of pine biomass on our State Forests than hardwoods compared to the rest of the state. Pines generally have a lower specific gravity and oven-dry weight (ODW) compared to hardwoods. For instance, white pine has an ODW of 26 lb/cf compared to 43 lb/cf for white oak (Miles and Smith 2009).

Carbon Stocks

Background

Taken together, forested ecosystems are the largest terrestrial sources for carbon storage on earth. Trees naturally sequester carbon, and in so doing, they help to offset emitted carbon dioxide to the earth's atmosphere from a variety of sources (such as the burning of fossil fuels). As described by Perry et al. (2012), the FIA program does not directly measure forest carbon stocks in Wisconsin. Instead, a combination of empirically derived carbon estimates (e.g., standing live trees) and models (e.g., carbon in soil organic matter are based on stand age and forest type) are used to estimate Wisconsin's forest carbon. Estimation procedures are detailed by Smith et al. (2006).

What we found

Wisconsin State Forests currently contain more than 45.7 million short tons of carbon. Soil organic matter (SOM) represents the largest forest ecosystem carbon stock at more than 30.5 million short tons, followed by live trees at more than 8.3 million short tons (Table 8). Within the live-tree pool, merchantable boles contain the bulk of the carbon, followed by roots and tops/ limbs.

Table 8. The distribution of carbon (short tons) by source.

Source	**Carbon (short tons)**
Soil organic	30,567,175
Live trees and saplings aboveground	7,722,925
Litter	3,369,709
Live trees and saplings belowground	1,611,446
Down dead	1,151,184
Standing dead trees	805,472
Understory aboveground	351,611
Understory belowground	39,068
Total	45,618,590

Early in stand development, most of the forest ecosystem carbon is in the SOM and belowground tree components. As forest stands mature, the ratio of above- to belowground carbon slowly shifts as carbon accumulates in live and dead aboveground components. Most of Wisconsin's aboveground live tree carbon stocks are found in stands between 61 and 100 years old (Table 9).

Table 9. Carbon (short tons) in live trees and saplings aboveground on forest land by stand age class and State Forest.

Stand Age Class (yrs)	NHAL	Black River	Brule	Coulee	Flambeau River	Gov. Knowles	Kettle Moraine NU	Kettle Moraine SU	Peshtigo River	Point Beach	All properties
0-10	49,533	10,585	8,320	-	10,960	2,838	2,136	249	-	-	84,620
11-60	1,342,589	533,470	333,132	38,296	622,172	112,815	191,342	113,726	67,662	16,869	3,372,071
61-100	1,703,421	229,824	110,405	29,003	895,389	103,521	249,050	135,745	95,411	41,285	3,593,054
100+	325,792	14,316	24,037	-	135,276	45,646	55,085	70,009	3,019	-	673,180
All classes	3,421,335	788,195	475,893	67,299	1,663,796	264,820	497,613	319,729	166,091	58,154	7,722,925

The largest amount of live tree carbon per acre is found on hardwood types such as maple/beech/birch

Table 10. Above ground carbon (short tons/acre) of live trees and saplings by forest type group and State Forest.

Forest type group	NHAL	Black River	Brule	Coulee	Flambeau River	Gov. Knowles	Kettle Moraine NU	Kettle Moraine SU	Peshtigo River	Point Beach	All properties
Maple/beech/birch	21.8	10.7	15.7	15.4	24.3	17.4	19.0	8.8	5.6	32.6	22.6
Oak/hickory	24.4	12.1	7.9	29.1	22.5	16.4	31.0	29.9	20.6	.	21.5
Exotic softwoods*	29.1	.	17.3	.	.	.	22.7	.	.	3.4	19.4
White/red/jack pine	21.4	14.9	17.7	.	26.8	13.2	19.9	23.4	24.1	20.8	19.1
Oak/pine	18.5	12.4	9.2	.	15.9	11.1	12.0	12.8	1.3	9.3	15.5
Elm/ash/cottonwood	9.8	13.2	14.8	.	18.1	13.9	12.3	10.1	20.4	19.5	14.6
Aspen/birch	13.9	6.4	12.4	22.6	12.5	8.5	19.6	14.0	16.2	17.5	13.2
Spruce/fir	6.2	7.7	14.3	.	10.4	19.0	15.9	10.2	21.8	22.5	7.9
Other hardwoods	3.4	0.7	0.2	.	14.3	.	12.4	.	.	.	2.9
Nonstocked	0.7	0.2	1.2	.	1.4	0.0	1.1	0.0	.	.	0.7
All groups	16.1	13.0	12.9	26.8	19.5	14.3	20.4	22.2	19.5	21.4	16.5

* Exotic softwoods include Scotch pine and Norway spruce.

and oak / hickory (Table 10). Five of the nine forest type groups have between 15 and 23 tons of carbon per acre with an average of 16.5 tons per acre for all groups.

The distribution of forest carbon stocks within each forest type can be quite variable. In the oak/hickory group, for example, 35 percent of the forest carbon is in live biomass, whereas in the spruce/fir group only 10 percent is in live biomass.

What this means

Total carbon stored by Wisconsin's State Forests is mostly found in younger stands but as these stands mature, increasing amounts of carbon accumulate in the above and below ground component. Although the highest amount of carbon per acre is found on hardwood types, the largest total amount of carbon is found on the pine types.

As carbon stocks continue to capture the attention of many stakeholders, managing forests beyond traditional growth and yield models will likely play an increasing role in our silvicultural considerations. Combining our knowledge of carbon storage in forests and the forest products derived from them through disciplines such as Life Cycle Analysis will further our understanding of this important issue.

Understory Vegetation and Habitat Type

Background

Species diversity

Vegetative diversity is a key indicator of the productivity of a site as well as habitat for wildlife and overstory species. Vegetation species composition data allow for species-based and community-based estimates including species diversity (Shannon's index) and frequency (the distribution of a species across a specified area). Shannon's index of diversity[2] is commonly used to characterize both the relative abundance and evenness of the species present. Changes in species diversity and composition, as well as structural diversity and the abundance of nonnative species are common national concerns.

Habitat type

Habitat types represent a system of site classification based on the floristic composition of understory vegetation. It is often used as an indicator of environmental factors such as soil fertility, competitive pressure, and expected growth and mortality rates of overstory species. Habitat types are represented along a gradient of moisture and nutrients from very dry and nutrient-poor to mesic and nutrient-rich.

What we found

Species diversity

Shannon's index was used to assess vegetative diversity on WisCFI plots (Table 11). The index tends to be lower (indicating less diversity) on properties which have a higher percentage of sandy soil and higher on properties which have more mesic soils. The canopy cover is higher on mesic soils as is the average total number of vegetative species present. Much of the State Forest land is comprised of sandy soils which have a lower average Shannon's diversity index. For instance, in seven of the ten State Forests over half of the timberland acreage is in sandy soils. These forests have a 14% lower diversity index than forests with heavier soils.

Vegetative diversity is highest on sites that are midway between very dry and wet (Figure 11). The highest values occur on dry-mesic to mesic sites. The forest types which show the highest diversity are

[2] Shannon's index of diversity is measured as $H = \sum pi\ (\ln pi)$ where pi is the proportion of total canopy cover in species i.

aspen/birch and elm/ash/cottonwood. The types which have the lowest values are either the pines which often occur on very dry sites and spruce/fir which occur on the wetter sites.

Table 11. Average characteristics of understory vegetation on the State Forests.

State forest	Number species per plot	Percent total canopy cover *	Site index	Shannon's index	Percent sandy soil**
Coulee Experimental Forest	55.3	184.5	64.8	2.62	0%
Governor Knowles State Forest	54.4	156.0	53.7	2.18	53%
Flambeau River State Forest	52.1	165.2	59.5	2.17	10%
Kettle Moraine State Forest – SU	47.7	172.6	60.0	2.13	27%
Kettle Moraine State Forest – NU	61.9	143.4	61.8	2.08	7%
Point Beach State Forest	47.3	161.7	47.7	2.00	75%
Brule River State Forest	47.9	142.7	59.1	1.97	58%
Peshtigo River State Forest	51.7	113.7	66.8	1.97	78%
NHAL State Forest	38.9	138.5	56.7	1.95	67%
Black River State Forest	37.2	124.1	56.3	1.82	76%
All State Forests	44.4	144.6	58.0	2.00	52%

* Canopy cover totals over 100% as species can overlap.
** Percentage of texture layer 1 on measured plots in sand and coarse sand. Unmeasured plots were excluded.

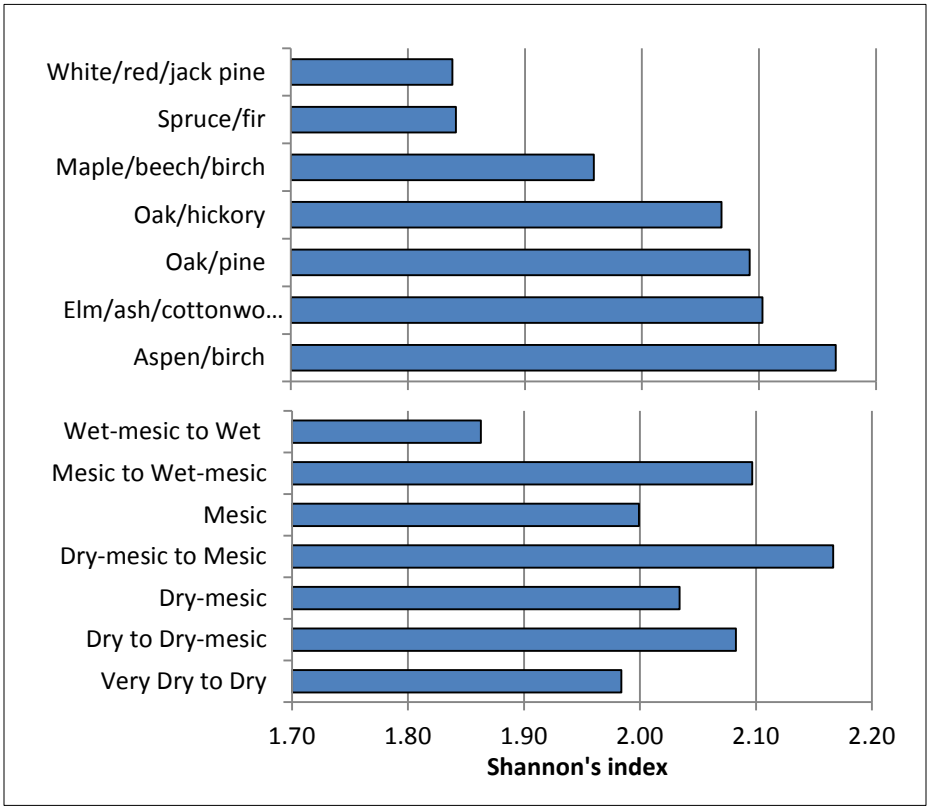


Figure 11. The average value of Shannon's index of diversity by forest type group (top) and habitat type group (bottom).

Habitat type

A comparison of the distribution of timberland acreage by habitat type group between State Forests and the state as a whole (Figure 12), reveals that there is a much higher percentage of land in very dry to dry habitat types on the State Forests, 27% compared to 10% statewide (Perry et al 2012). This is probably due to the predominance of sandy soils in several State Forests. For instance, in five of the ten State Forests (Black River, Brule River, Northern Highland American Legion, Peshtigo River and Governor Knowles), at least 60% of soils are classified as sand. The majority of acreage in the Coulee Experimental Forest and both units of the Kettle Moraine State Forests is classified as dry mesic to mesic whereas timberland acreage in the Flambeau River State Forest is evenly divided between mesic and mesic to wet-mesic. Soils in these four forests are at least 60% loamy or organic.

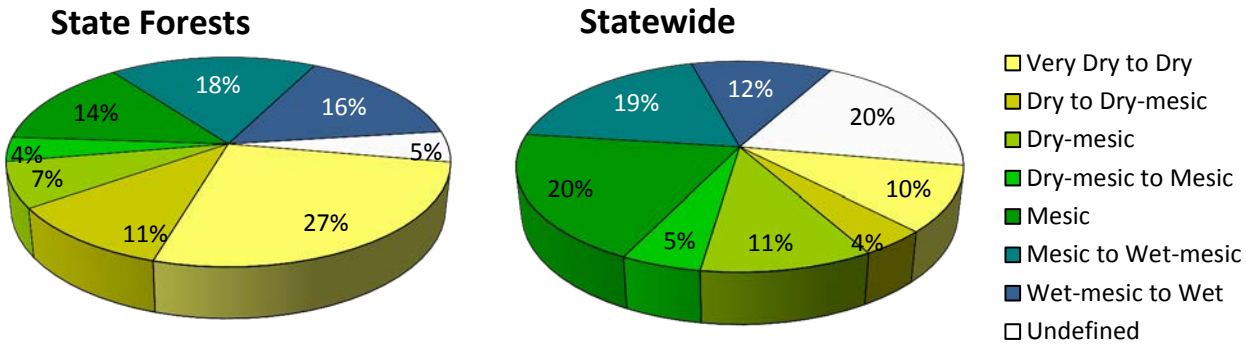


Figure 12. A comparison of the distribution of land by habitat type group between the State Forests (left) and all state timberland (right).

Over half of timberland classified as very dry to dry is dominated by three forest types: red pine, aspen, and oak. Over half of dry mesic to mesic as well as mesic timberland is in oak and central hardwoods. Mesic to wet-mesic sites are dominated by aspen, red maple, and white pine forest types.

There is also a higher percentage of "Undefined" acreage in the statewide analysis (Perry et al 2012) due to the higher likelihood of encountering very disturbed land on private property.

What this means

Because much of the State Forest property is located on sandy soils, the diversity of vegetative species is lower than on other forest land (Figure 13). The forests with the highest diversity include the Coulee Experimental Forest, Governor Knowles State Forest, the Flambeau River State Forest, and the Kettle Moraine State Forest both units.

The habitat types that support the highest diversity of understory vegetation are types have soils of medium moisture and nutrient value. Very dry and very wet sites may require habitat specialist species that can tolerate more extreme conditions. There are more species that thrive on medium sites than at the extremes.

The forest type that supports the highest diversity is aspen/birch and the lowest diversity is found on pine and spruce/fir sites. The canopies of aspen/birch stands tend to allow more light to the understory which permits a wider variety of vegetative species to grow. Pines tend to thrive on drier sites and spruce/fir on wetter sites which, as mentioned, restricts the number of species that can tolerate these extreme conditions.

Figure 13. Much of the State Forest land consists of dry sands with very sparse understory vegetation.

Dry nutrient-poor habitat types can present both challenges and unique opportunities. For instance, trees growing on droughty soils are more susceptible to disease-related mortality and slow growth. Pest issues that on better sites might merely cause growth reduction can easily kill trees on dry sites especially when combined with seasonal drought. However, dry nutrient poor sites can also provide habitat for unique and rare species and rare ecosystems, like barrens.

The ten State Forests have over 35% of their total timberland acreage in oak and pine forest types and much of this is on the droughtiest soils. Forest management can reduce disease pressure by maintaining healthy stands of these species.

HEALTH INDICATORS

Crown Conditions

Background

The condition of tree crowns within a stand may reflect the overall health of a forest. For example, a forest suffering from a disease epidemic will have obvious dieback, low crown ratios, and high transparency (Figure 14).

Figure 14. Crown dieback and transparency may reveal underlying disease and pest issues.

What we found

Crown Dieback

Dieback is defined as the percentage of branch tips in the crown that are dead. The categories for the dieback indicator are none (0 to 5 percent), light (6 to 20 percent), moderate (21 to 50 percent), and severe (51 to 100 percent). Figure 15 shows a comparison of the number of growing stock trees in each of these categories on State Forests (left) and statewide (right).

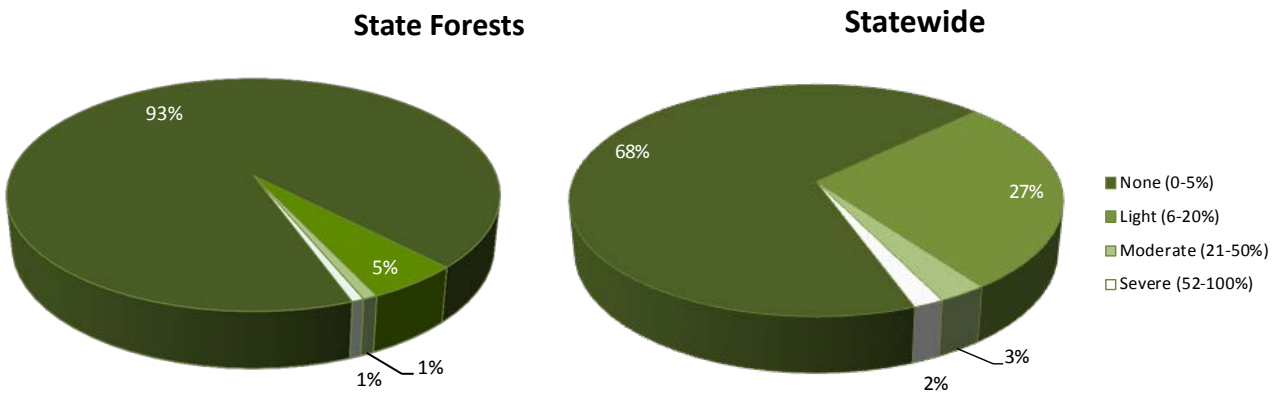


Figure 15. A comparison of the percentage of trees by crown dieback category between State Forests (left) and statewide (right, Perry et al 2012).

Tree crowns generally are healthy across Wisconsin but especially so on the State Forests. For instance, 93% of trees on the State Forests show no signs of dieback compared to 68% for the entire state. Very few trees show moderate to severe dieback.

The species with the poorest crown conditions, defined as having at least 3% of trees with moderate to severe dieback, are northern pin oak (8% dieback), black ash (5%), paper birch (5%), black cherry (4%), red maple (4%), yellow birch (3%), and northern red oak (3%).

Foliage transparency

Foliage transparency is defined as the amount of skylight visible through the live, normally foliated portion of the crown, excluding dieback, dead branches, and large gaps in the crown. Average crown transparency on the State Forests was lower for all species group compared to statewide averages (Figure 16, Perry et al 2012).

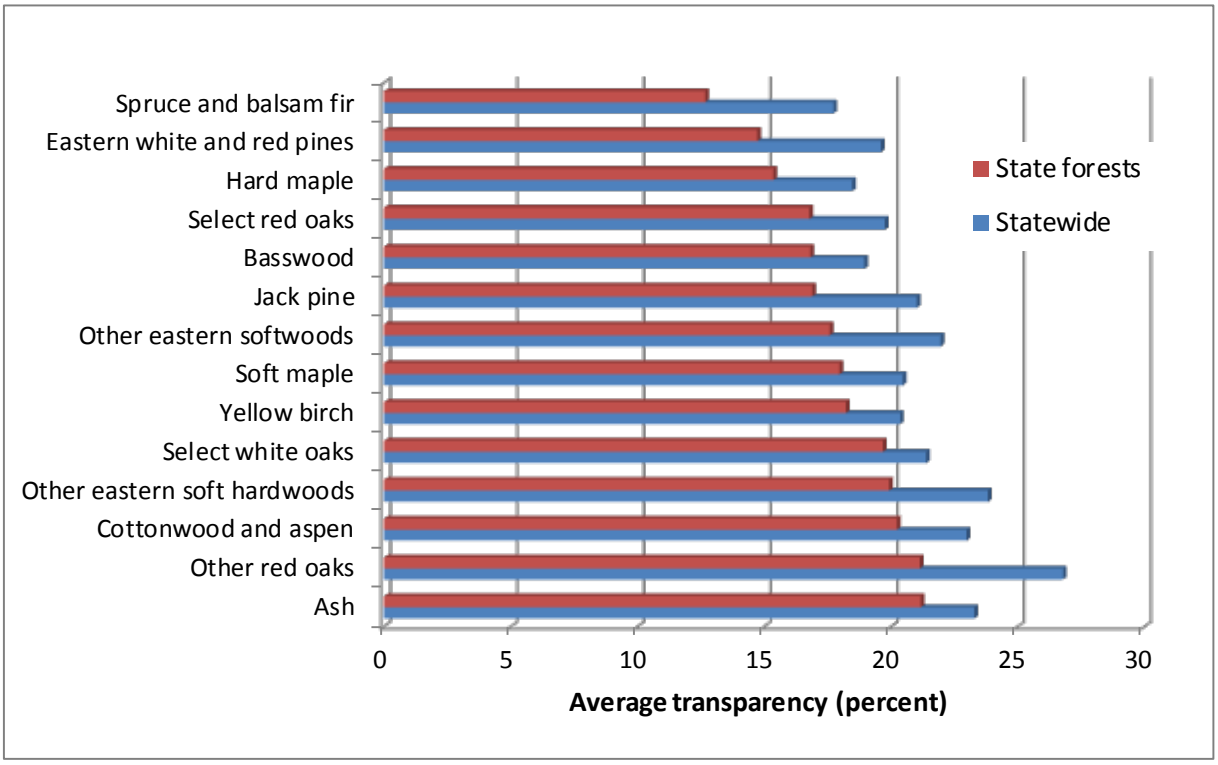


Figure 16. Average transparency by species on the State Forests compared to statewide.

Species naturally differ in transparency with conifers and tolerant deciduous species having lower foliage transparency values. The ashes, northern pin oak and black cherry have the highest average transparency. Northern pin oak, black ash and black cherry also have high values for average crown dieback.

What this means

When considering crown dieback and crown transparency by tree species, certain species rank high for both. These include black cherry, northern pin oak, the ashes, paper birch, American elm and black oak. Several of these species had a high mortality ratio[3] statewide in 2011 (Perry et al 2012), especially paper birch, American elm, black oak, and northern pin oak (144%, 98%, 75% and 42%, respectively). Ash species have a very low average mortality ratio (15%).

High levels of crown dieback and transparency may be due to causes related to natural succession as shade intolerant species, such as paper birch and aspen, give way to more tolerant ones. However, they may also indicate deteriorating forest health conditions. This is probably the case with the elms which have suffered high mortality due to Dutch elm disease. Black oak and northern pin oak are very susceptible to both oak wilt and two-lined chestnut borer, especially on sandy soils. Almost ¾ of black and pin oaks on the State Forests are located within oak wilt affected counties (Figure 17) and mostly on very dry habitat types. This situation can be exacerbated by drought, as occurred in 2007 and 2009 (see Forest insects and diseases, p 36).

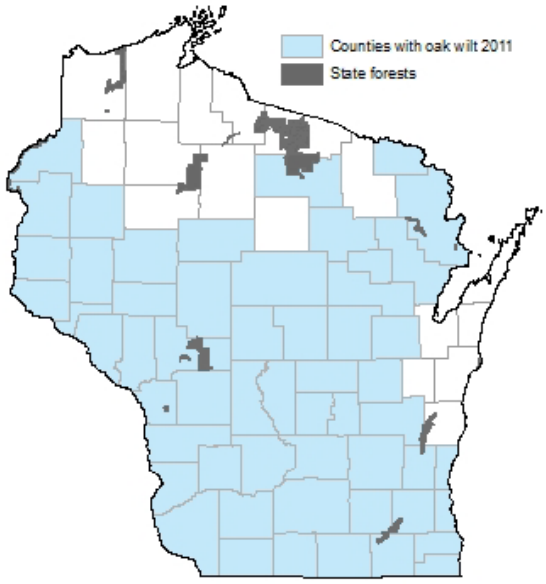


Figure 17. Location of the State Forests in relation to counties in which oak wilt has been recorded.

[3] Mortality ratio is defined as the ratio of mortality (cft) to gross growth (cft) of growing stock on timberland. A mortality ratio near 100% means that as much wood volume is lost by mortality as is gained through growth.

Down Woody Materials

Background

Down woody materials or coarse woody debris (CWD) are defined as dead woody plant materials such as tree limbs, tree boles or shrubs greater than 3" in diameter. Standing dead trees are also considered CWD if they are leaning > 45 degrees from vertical.

Coarse woody debris (Paul Bolstad, University of Minnesota, Bugwood.org)

CWD is an important component of forest structure and function. Large, decayed pieces of CWD provide the necessary microhabitat for the germination of a few key Wisconsin tree species, including yellow birch (*Betula alleghaniensis*) (Stupka 1964) and eastern hemlock (*Tsuga canadensis*) (Knechtel 1903). CWD is not only important to tree regeneration, but also provides valuable habitat and food to birds, mammals, arthropods and herptiles (Hagan and Grove 1999).

CWD was quantified by establishing three 24 ft. transects (30, 150 and 270 azimuths degrees) at each of the WisCFI subplots. Each piece of CWD was assigned a specific decay classification ranging from fresh (1) to highly decayed (5). For specific decay-class characteristics see (Table 12). Diameters and lengths of the CWD were measured for each piece that intersects any of the transect lines. These measures of diameter and length allow for the volume to be calculated and expressed as cubic feet (cuft). Total CWD volume was divided by the acreage of each State Forest property to normalize CWD volume (cuft) per acre.

What we found

Decay-classes range from (1) least decayed to (5) most decayed (for specific characteristics of decay classes, see Table 12). Of the quantified CWD, decay class 3 was the most common, comprising 50% of all CWD (Figure 18). Decay class 3 is described as having sound heartwood, but sapwood could be pulled apart by hand or was absent.

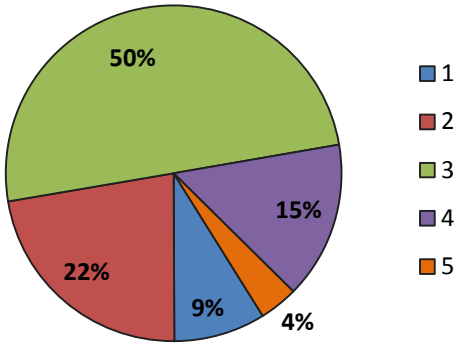


Figure 18. Decay-class distribution of coarse woody debris.

The second most common decay class was (2), which not only has sound heartwood, but mostly intact

Table 12: Decay classification characteristics used to determine the level of decay for each piece of coarse woody debris (CWD). Table has been recreated from the Wisconsin State Forests Continuous Forest Inventory Field Guide version 2.0.

Decay Class	Structural Integrity	Texture of Rotten Portions
1	Sound, freshly fallen, intact logs	Intact, no rot; conks of stem decay absent
2	Sound	Mostly intact; sapwood partly soft (starting to decay,) but can't be pulled apart by hand
3	Heartwood sound; piece supports its own weight	Hard, large pieces; sapwood can be pulled apart by hand or sapwood absent
4	Heartwood rotten; piece does not support its own weight, but maintains its shape	Soft, small blocky pieces; a metal pin can be push into heartwood
5	None, piece no longer maintains its shape, it spreads out on ground	Soft; powdery when dry

sapwood. The least common decay class was decay class (5), which is the most highly decayed CWD possible.

The mean volume of CWD was calculated for each of the five size classes ranging from 3.0-7.9 inches through greater than 23 inches (Figure 19). The two most common size classes were the two smallest size classes 3.0-7.9 inch and 8.0-12.9 inch. The least common size of CWD was in the larger size class distribution, specifically 18.0-22.9 inch and 23.0+ inches.

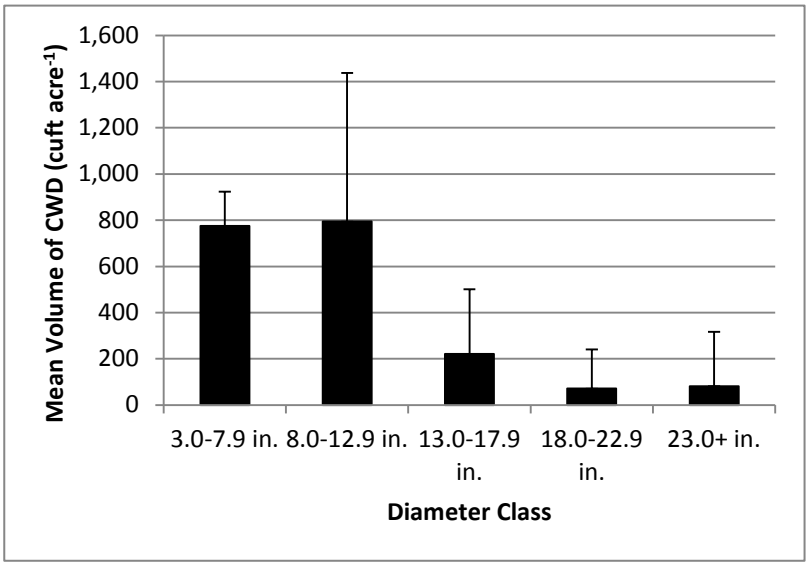


Figure 19. Mean distribution of coarse woody debris (CWD) by diameter class for Wisconsin State Forests.

Of the ten State Forests only Peshtigo River State Forest, Flambeau River and Northern Highland American Legion had CWD greater than 18.0 inches (Figure 20). Only Northern Highland American Legion State Forest and Flambeau River State Forest had CWD in the 23.0+ inch size class. Of the CWD in the 23.0+ inch size class, 91% was located in the Northern Highland American Legion State Forest.

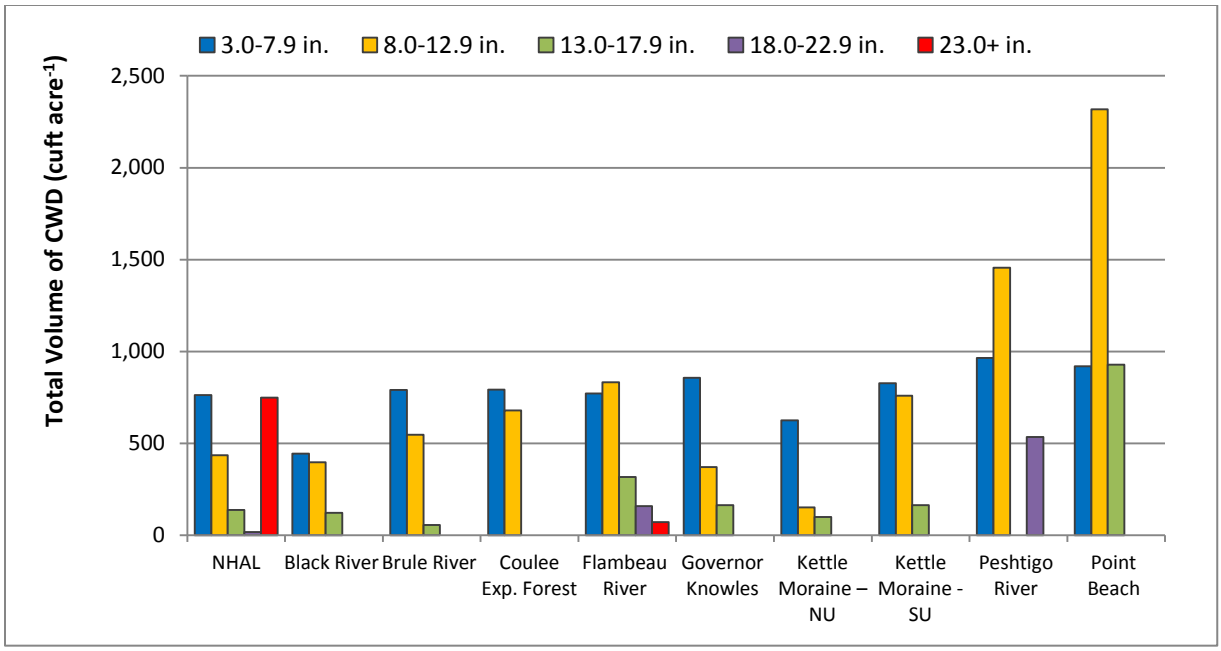


Figure 20. Total volume of coarse woody debris (CWD) by diameter class for individual State Forests.

What this means

The WisCFI CWD data corroborated previous CWD estimates by Goodburn and Lorimer (1998), which investigated CWD across Northern Wisconsin and the Upper Peninsula of Michigan. Data presented in this report and in Goodburn and Lorimer show decay-class 3 being the most prevalent decay-class for the surveyed forests. While decay-class 3 is usually most common in old-growth forests, the amount of highly decayed CWD (decay class 5) was considerably lower for State Forests properties (4%) compared to old growth forests (16%) (Goodburn and Lorimer 1998). The lack of highly decayed CWD negatively affects specific plant germination, which is facilitated by using highly decayed CWD as a seed bed (Harmon 1986). Small mammals like martens (Payer and Harrison 2003) as well as voles, mice, shrews and lemmings (Fauteux et al. 2012), also make use of highly decayed CWD.

However, the level of decay is not the only factor when considering the ecosystem function of CWD. The size of the CWD plays an equally important role in providing the needed size structure for fauna habitat. Eight of the ten State Forests failed to have any CWD greater than 23 inches in size. This lack of large CWD is common for managed forests (Gore and Patterson 1985). Gore and Patterson (1985) show similar results for northern forests of New Hampshire, with large (>38 cm or 15 in.) CWD being notably absent in managed forests, unlike unmanaged forests.

Finally, Wisconsin State Forests showed an overall lack of CWD volume. Average CWD volume across all Wisconsin State Forests was 182.6 cft/acre. This average CWD volume is low even for managed forests, as both Goodburn and Lorimer (1998) and Duvall and Grigal (1999) report CWD volumes of approximately 285 cft/acre for managed forests and approximately 1,427 cft/acre for unmanaged forests.

Forest Insects and Diseases

Background

Insects and diseases have always been a part of Wisconsin's forest ecosystem and State Forests certainly are subject to their impact. In the past decade, the threat and impact from exotic insects and diseases has increased as the number of them established in Wisconsin and the United States increases. These impacts are especially prominent on public lands which receive greater traffic from areas where exotic pests are well established. Combined impacts from multiple stressors, both living and non-living, also appear to be an increasing problem.

What we found

Wisconsin's State Forests experienced impacts from weather and a variety of insects and diseases from 2007 to 2011. This period was characterized by diebacks and declines in several tree species due to multiple factors. Northern Wisconsin counties experienced drought during the growing season in 2007 and 2009 (Figure 21). Drought affected several State Forests including the Brule River State Forest,

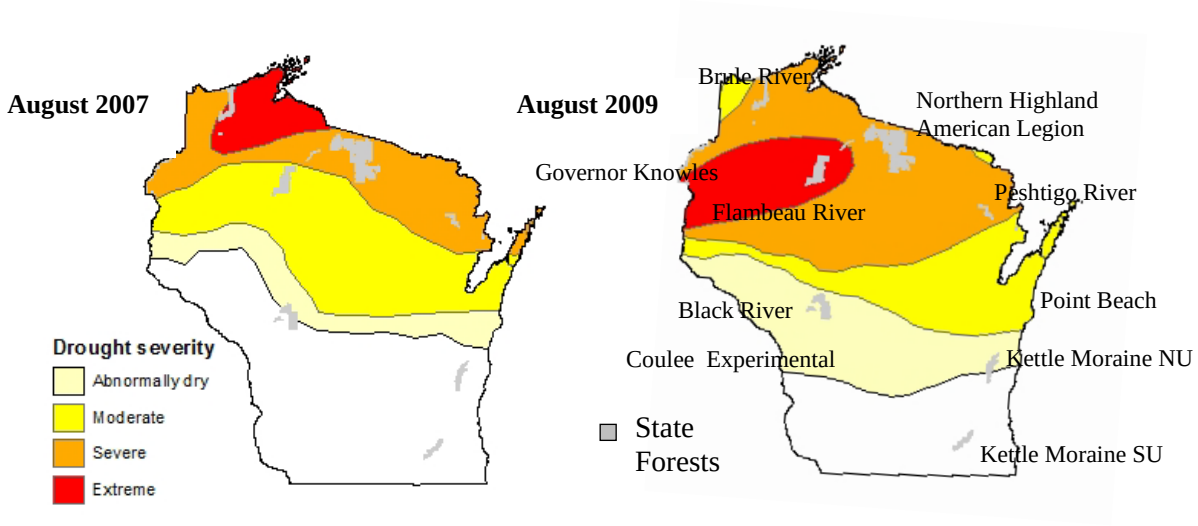


Figure 21. Several of the State Forests were affected by severe drought during the summer of 2007 and 2009.

Flambeau River State Forest, Governor Knowles State Forest, Northern Highland American Legion State Forest and Peshtigo River State Forest .

Stress from drought is likely to cause trees to be more susceptible to a variety of opportunistic pests and diseases. For instance, aspen which accounts for 25% of all trees in these northern forests is affected by *Armillaria* root disease, Hypoxylon canker (*Entoleuca mammata)*, bronze poplar borer (*Agrilus granulatus liragus)*, and gypsy moth (*Lymantria dispar)*. Oak which accounts for 5 percent of trees on

the State Forests is affected by gypsy moth (*Lymantria dispar*), two-lined chestnut borer (*Agrilus bilineatus)*, and oak wilt (*Ceratocystis fagacearum).* Red pine which accounts for another 4 percent of all State Forest trees is affected by *Armillaria* root disease, Diplodia shoot blight and collar rot (*Diplodia pinea*), pine engraver (*Ips pini*), and red turpentine beetle (*Dendroctonus valens).* All of these pests and diseases are closely related to drought conditions.

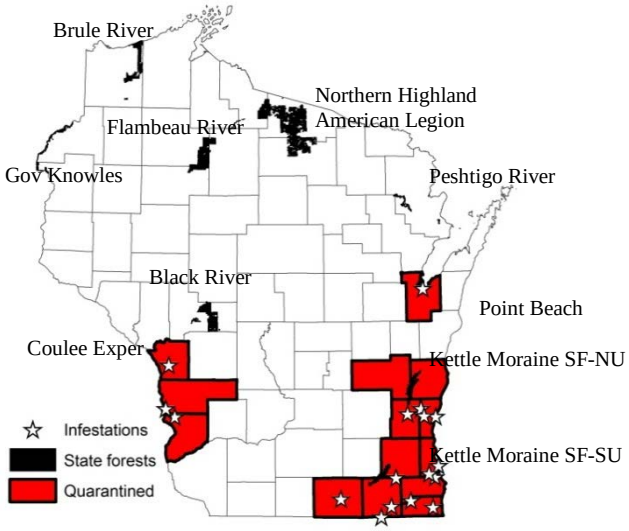


Figure 22. Emerald ash borer infestation sites, quarantined counties and State Forests (summer 2012).

Emerald ash borer (*Agrilus planipennis)* is a recent invader of special concern to ash trees in Wisconsin. This pest has been found in 12 counties as of fall 2012 (Figure 22). Ash species make up only 4 percent of our State Forest trees but are more common on certain properties. These include Kettle Moraine State Forest Northern Unit (24% of all growing stock trees), Goveror Knowles State Forest (12%), Flambeau River State Forest (9%), Peshtigo River State Forest (7%) and the Brule River State Forest (6%). As of spring 2012, this pest had not yet been reported on any of the State Forests.

Another emerging problem on red pine is Annosum root disease (*Heterobasidion irregulare*). As of spring 2012, there were 55 stands in Wisconsin that had been identified with this disease, several of them on the Kettle Moraine State Forest – Southern Unit (KMSU). A map of proximity zones based on both distance between infected stands and the severity of infection within each stand was created (Figure 23) to help delineate risk to the State Forests. Apart from the KMSU where the disease is already established, State Forests that are located in areas of moderate risk due to proximity include the Black River State Forest, the Coulee Experimental Forest and the Peshtigo River State.

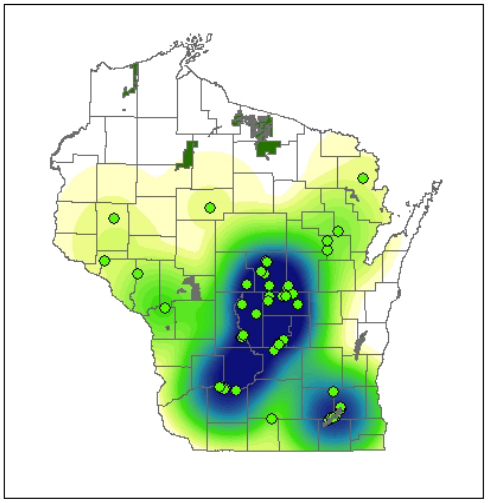


Figure 23. There are 55 stands where Annosum has been reported in Wisconsin as of 2011 (green dots). Risk ranges from the highest (dark blue) to medium (green) to very low (no color).

What this means

Decline, dieback and mortality of trees due to the combined stress of multiple factors, both living and non-living, has occurred in previous decades and can be expected in the future. It should be recognized, however, that the initial source of stress that opens trees to attack by opportunistic or weak pests and diseases is often weather events such as drought, storm damage, frost or flooding. Wisconsin has experienced warming weather in the last two decades and a changing climate will cause an increase in the background level of stress experienced by trees leaving them increasingly susceptible to the accumulation of stress from minor or secondary pests and diseases.

Conk of *Heterobasidium irregulare* (Sally Dahir, WIDNR)

Invasive pests and disease have the potential to change forest composition, some in dramatic ways and others more subtlety. Wisconsin's State Forests may be exposed to higher levels of introduction risk compared to private lands due to high vehicle and pedestrian traffic from areas already infected. Insects and spores can be easily transported on vehicles, firewood, clothing, etc. The future will present a real challenge for our State Forests as they deal with the combined stresses of invasive insects and diseases combined with extreme weather patterns.

Soils

Background

Soils perform a number of vital functions in the ecosystem. They "redistribute precipitation, filter and decontaminate aqueous solutions and suspensions, make mineral nutrients available to plants and animals and people, and support structures such as roads and buildings" (Hole 1976). Knowing the soils of an area is a way to 'read' the landscape, to determine among other things, which plant communities will be sustained, which tree species will survive and thrive, and how well a landscape can tolerate abiological events such as drought, storms and flooding.

What we found

As discussed earlier in the report, many of the State Forests were established on agricultural land which

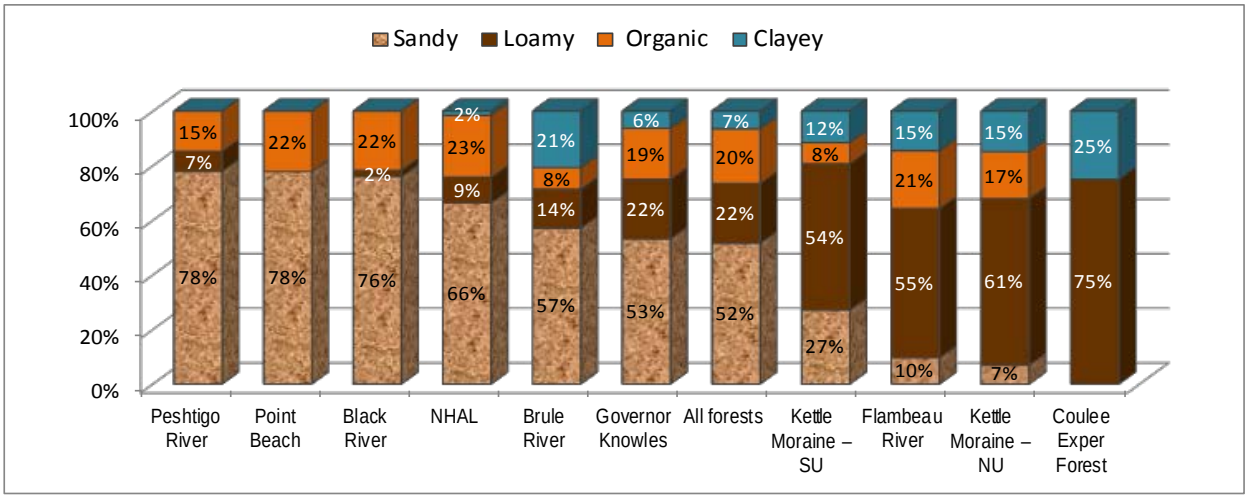


Figure 24. The percentage of acreage by soil texture in the top four inch layer for each of the State Forests.

was abandoned due to unproductive soils and a short growing season. In seven of the State Forests over half of the forest land is sandy, either sand or coarse sand (Figure 24). Four of the State Forests have a majority of loamy soils, both units of the Kettle Moraine, the Flambeau River State Forest and the Coulee Experimental Forest. The top soil layer in Point Beach State Forest, Peshtigo River State Forest and Black River State Forest is almost entirely either sandy or organic soil. Only 1.3% of all forest land in the State Forests is bare soil and 8% of all soil is compacted (Table 13). There are ruts[4] on only 3% of all measured subplots (N=1,474). The forests with the highest amount of bare soil are both units of the Kettle Moraine State Forest (sampling error for Point Beach State Forest is too high to make valid

[4] A rut an elongated depression in a trail or roadway caused by dragged logs or by wheels or tracks of harvesting machinery and is often exacerbated by erosion from uncontrolled storm water runoff. It must be at least two inches deep into mineral soil.

conclusions). The forests with the highest percentage of compacted soil include the Kettle Moraine State Forest NU, Black River State Forest and Northern Highland American Legion State Forest. The highest

Table 13. Area of compacted and bare soil and percent of subplots with ruts by State Forest property.

State Forest	Area of compacted soil (acres)	Percent total forest land	Area of bare soil (acres)	Percent total forest land	Percent of subplots with ruts		
					No ruts	1-2 ruts	3-5 ruts
Black River State Forest	6,720	11	537	0.9	94.6	4.7	0.7
Brule River State Forest	3,139	8	253	0.7	97.9	1.0	1.0
Coulee Experimental Forest	-	0	41	1.6	100.0	-	-
Flambeau River State Forest	2,901	3	440	0.5	96.8	3.2	-
Governor Knowles State Forest	1,229	7	216*	1.2	95.7	-	4.3
Kettle Moraine State Forest – NU	3,255	13	1,110	4.5	100.0	-	-
Kettle Moraine State Forest – SU	1,356	9	737	5.1	100.0	-	-
NHAL State Forest	20,412	10	2,672	1.3	96.8	2.4	0.8
Peshtigo River State Forest	562	7	88	1.0	100.0	-	-
Point Beach State Forest	46*	2	162*	5.9	100.0	-	-
All State Forests	39,620	8	6,255	1.3	96.9	2.4	0.7

* Sampling error greater than 50%

percentage of subplots with ruts occurs on the Black River State Forest. Improved roads are excluded from this analysis.

What this means

Sandy soils (in the top 4 inch texture layer) account for over half of the acreage of the State Forests. These soils are generally less productive and support far fewer plant and trees species compared to heavier soils. Trees on sandy soils are more prone to disease and pest issues, especially during periods of drought.

Organic or peaty soils, which account for another 20% of the acreage of State Forests, are also less productive soils. Almost 80% of organic soils produce less than 50 cuft/acre/yr of wood. Organic soils may be more prone to abiotic disturbance, especially strong winds and drought.

The proportion of bare soil is very low on the State Forests in general. The two units of the Kettle Moraine State Forest have a higher proportion of bare soil. Compaction also tends to be higher on the Kettle Moraines. Compaction is also above average on the Black River State Forest and on the Northern Highland American Legion State Forest. This may be related to high levels of harvest. In 2010, these two forests accounted for about half of all timber products (cords and sawlogs) harvested on State Forests annually.

Invasive Plants Species

Background

Nonnative plants can be detrimental to native forest ecosystems, threatening ecological diversity, ultimately increasing forest management costs through their impact on forest tree regeneration and growth, and limiting management options. Preventing the spread of invasive plants is a critical part of slowing the spread.

What we found

The inventory identified 25 species of non-native invasive plants on State Forests (Figure 25). The most

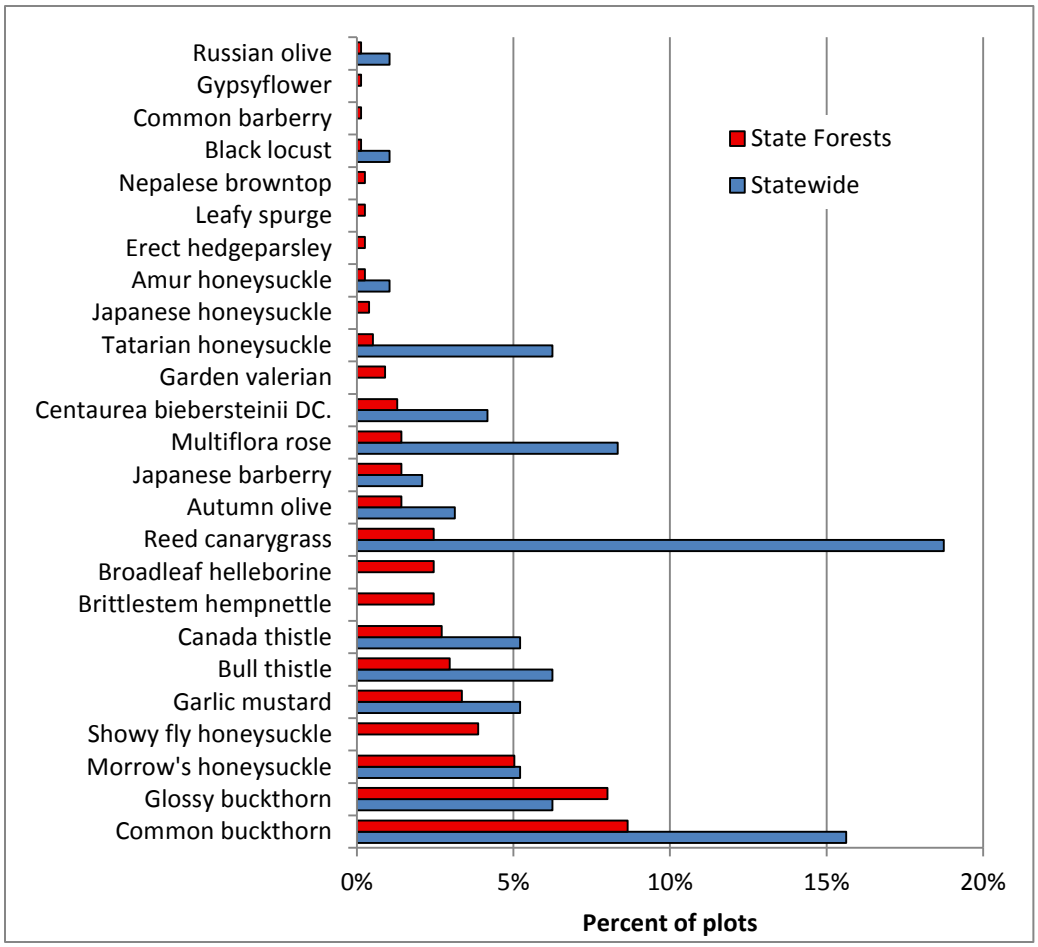


Figure 25. Frequency of occurrence of invasive plants on State Forests (2011 data) and statewide (2009 data)

common species are non-native shrubs, primarily buckthorns and honeysuckles. The frequency of occurrence on state lands is generally less than the statewide data of 2009, with the exception of a few species, notably glossy buckthorn (Perry et al 2012). The southern State Forests (KMSF-NU, SU) have

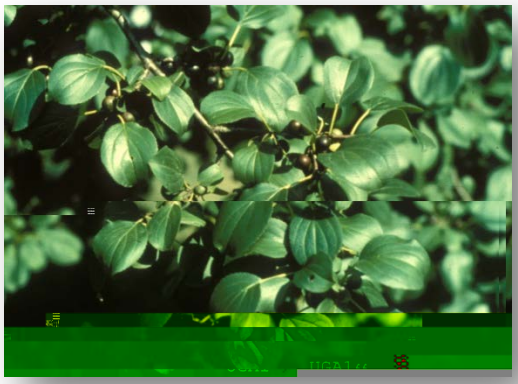
the greatest number of acres of invasives based on vegetative cover with a high of 4,073 on the KMSF-SU. The Black River State Forest has 284.4 acres, while the Northern Highland American Legion State Forest has 35.9 acres.. The State Forests with the two lowest number of tree seedlings per acre, other than Point Beach are the two units of the Kettle Moraine (Figure 26).

Table 14. Characteristics related to vegetative diversity on the individual State Forests.

State forest	Vegetative cover of invasive species (acres)	Average % total acreage in invasives	Tree seedlings per acre	Average percent acreage in sandy soil
Black River SF	284.4	0.68	3,503	76%
Brule River SF	19.3	0.06	5,072	58%
Coulee Exper Forest	4.1	0.21	3,482	0%
Flambeau River SF	111.6	0.15	4,145	10%
Governor Knowles SF	17.9	0.12	3,009	53%
Kettle Moraine SF – NU	1,018	5.59	2,925	7%
Kettle Moraine SF – SU	4,073	28.93	1,536	27%
NHAL SF	35.9	0.02	3,913	65%
Peshtigo River SF	0.1	0.00	3,129	78%
Point Beach SF	10.2	0.57	668	75%
All State Forests	5,574	1.25	3,801	52

What this means

Although nonnative plant species represent a minority of species in Wisconsin's forests, they are a forest health concern because they can out-compete native plant species, including trees, and threaten ecological diversity by altering natural plant communities and alter beneficial soil properties. Some species already are distributed across the state but several are not, and this may present managers with opportunities for limiting range expansion. The vegetation diversity sample is relatively small; the increasing numbers of several invasive species requires continued attention to determine if this is a long-term trend.



Common buckthorn (Richard Webb, Bugwood.org)

The vegetative cover of invasive species in acres shows a trend that the southern forests are more infested than the north. This may be partly explained by proximity to large urban areas and to adjacent states like Illinois where invasive species are already well established. Also, due to a higher exposure to agriculture,

these southern forests have experienced longer and higher levels of cutting and grazing disturbance. The number of tree seedlings per acre appears to be directly correlated to the invasive plant vegetative cover. We can conclude that as the number of invasive plants increase and the vegetative cover increases, tree seedlings will likely decrease. Invasive plants are continuing to enter the state and are continuing to be

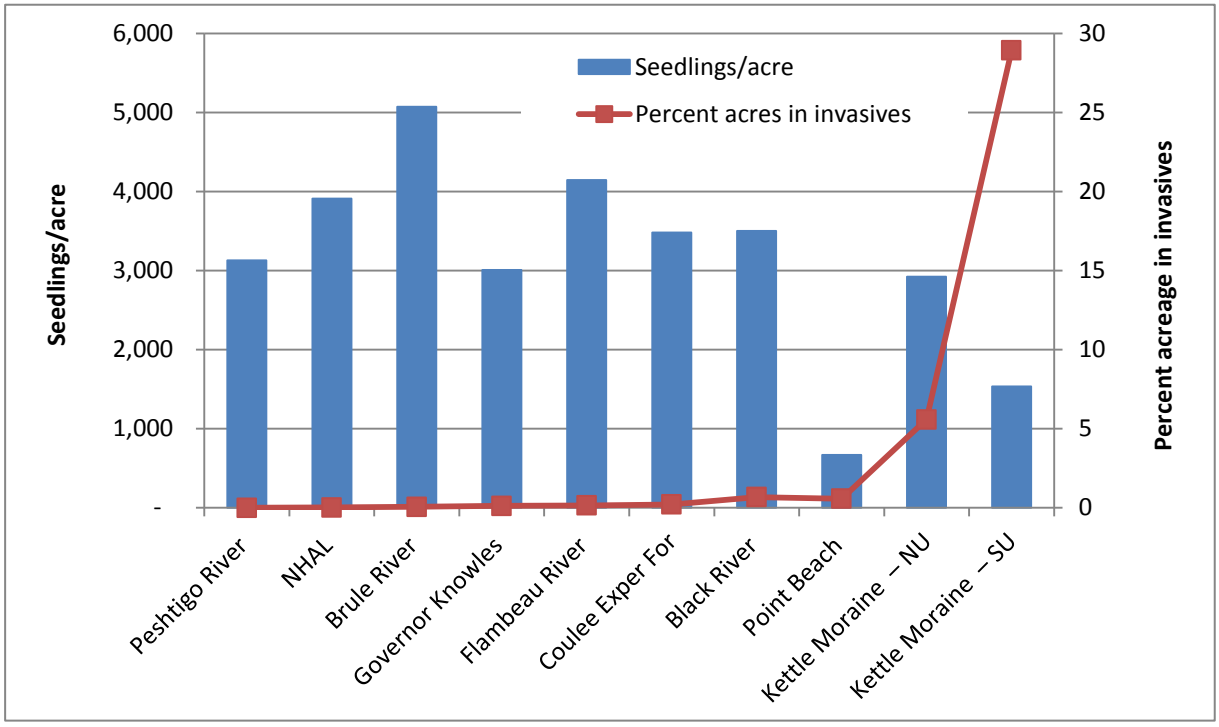


Figure 26. The number of tree seedlings per acre compared to the percent acreage in invasives by State Forest.

spread by human pathways, again emphasizing the importance of preventing the spread to areas which are currently relatively free of invasives.

Disturbance

Background

Temporary disturbances to the forest canopy are common in Wisconsin. Forest canopy disturbances result from a wide variety of causes, including animal damage (including grazing), wind, water, fire, insects and disease, all of which impact forest ecosystem composition, structure and function. Severity of disturbance is affected by the susceptibility of trees (e.g., rooting depth) and the intensity of the disturbance agent (e.g., wind speed).

What we found

Of the 2,611 forested plots representing over 455,000 acres, 2,533 (443,000 acres) or 97% were reported as having no visible disturbance. Of the approximately 13,000 acres that were disturbed between 2007 and 2011, slightly less than half was due to weather events including wind and fire, and another third was due to insects and diseases (Figure 27). Fire was the dominant disturbance on Governor Knowles State Forest, wind was dominant on the Flambeau River State Forest, and insects and disease accounted for all

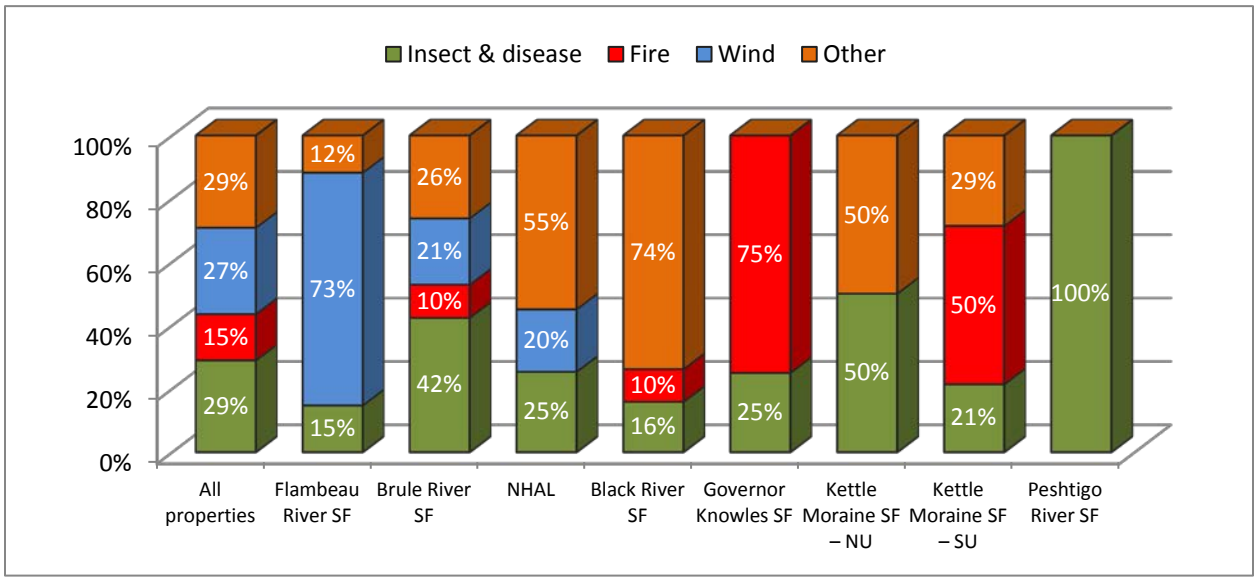
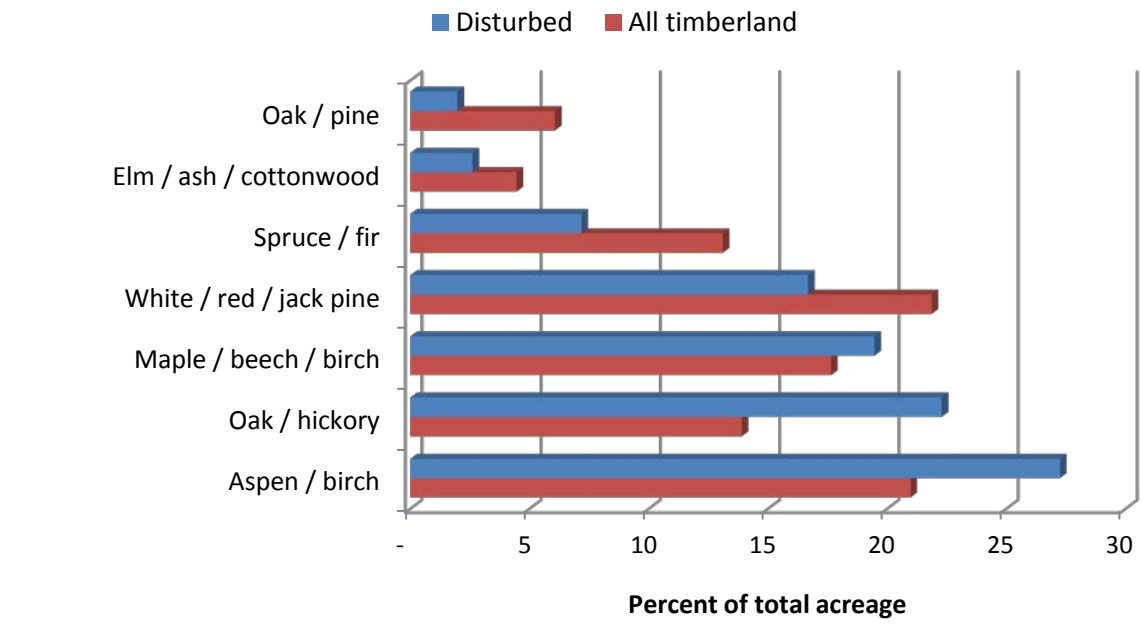


Figure 27. The percent of disturbed area by State Forest and cause of disturbance.

the recorded disturbance on the Peshtigo River State Forest.

The forest type groups most affected by insects and disease are oak/hickory, white/red/jack pine and aspen/birch whereas the types most affected by fire and wind are maple/beech/birch and aspen/birch.

The forest type group which showed the highest percentage of total acreage disturbed was aspen/birch (Figure 28, top) followed by oak/hickory. The type with the greatest difference between the percentage of disturbed acres compared to the percentage of total acres in that type was oak/hickory. This forest type



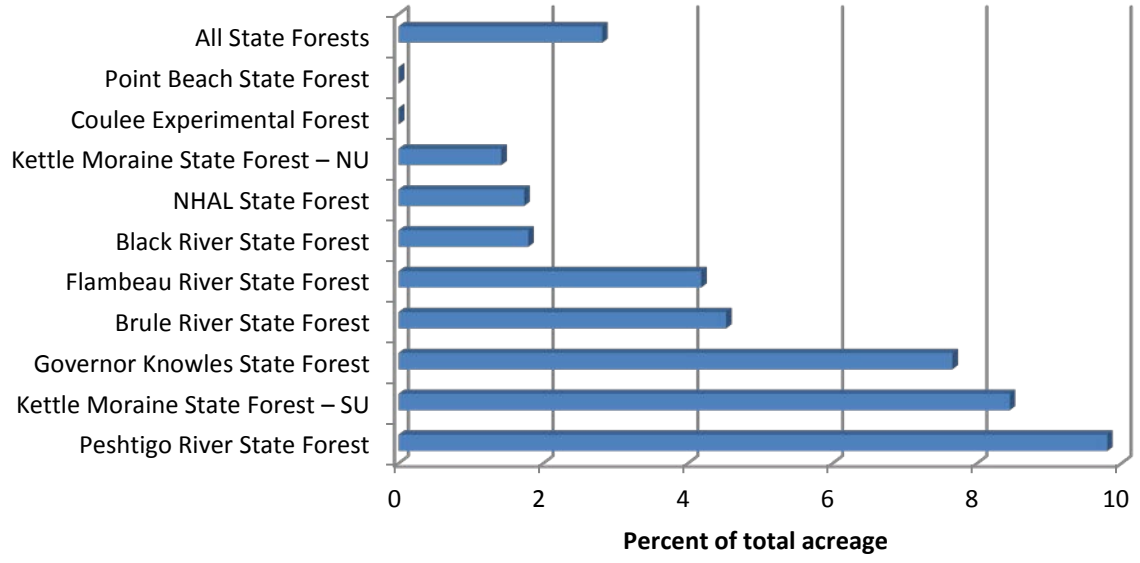


Figure 28. Top: Percent of all timberland acreage and percent of disturbed acreage on the state forests by forest type group. (For instance, aspen/birch accounts for 21% of all timberland in the State Forests but over 27% of all disturbed acres.)
Figure 28. Bottom: Percent of property acreage which is disturbed.
The sampling error for disturbed acreage was below 50 percent for all properties except the Kettle Moraine State Forest-NU.

group makes up 14% of total timberland acreage but 22% of all acres disturbed.

The properties which had at least 5 percent of their acreage disturbed were the Peshtigo River State Forest (9.8%), Kettle Moraine State Forest –Southern Unit (8.5%), and Governor Knowles State Forest (7.7%, Figure 28 bottom).

What this means

Wind and fire combined are responsible for the majority of disturbance. Wind alone accounts for 27% of disturbed timberland acreage on the State Forests. Weather-related disturbances are often short term but spatially wide spread. Insects and disease, on the other hand, may have a greater effect over time but not affect a large area at any one point in time. For example, oak wilt and Annosum root disease will affect small pockets of trees initially but can affect large areas over many years. There are certainly exceptions to this during periodic outbreaks of pests such as jack pine budworm, spruce budworm or forest tent caterpillar.

Blowdown in northern WI, April 12, 2011 (Brian Schwingle, WIDNR)

The oak/hickory forest type seems to be most affected by disturbance as far as percentage of acres disturbed compared to total acres. Most of this disturbance is due to insects and diseases. The majority of oak/hickory in the State Forests is on sandy soils which may aggravate diseases such as oak wilt, gypsy moth, oak decline and two-lined chestnut borer.

FOREST ECONOMICS

Growing Stock Volume

Background

The growing-stock volume on timberland in Wisconsin's ten State Forests accounts for a significant portion of the resource statewide, which is an important driver of local and state economies (Perry et al 2012). Wisconsin continues to lead the nation in paper production, while other wood product sectors remain important to the state's economy. Establishing the current growing stock volume and distribution of certain tree species helps to evaluate the effects of paper and lumber production as well as estimate future timber productivity. Future analysis will incorporate growth, removals and mortality to assess changes in the timber resource on Wisconsin's State Forests.

What we found

The total volume of growing stock on timberland in 2011 in Wisconsin's State Forests is estimated at 567.1 million cubic feet (MMCF). This volume accounts for 2.6% of the total growing stock on timberland in the state as a whole (21.4 billion cubic feet). Growing-stock volumes by species group follow similar patterns on State Forests as on statewide timberland (Figure 29, Perry et al 2012). The eastern white and red pines group has the largest volume in Wisconsin's State Forests, 191.6 MMCF . This accounts for over one third of total

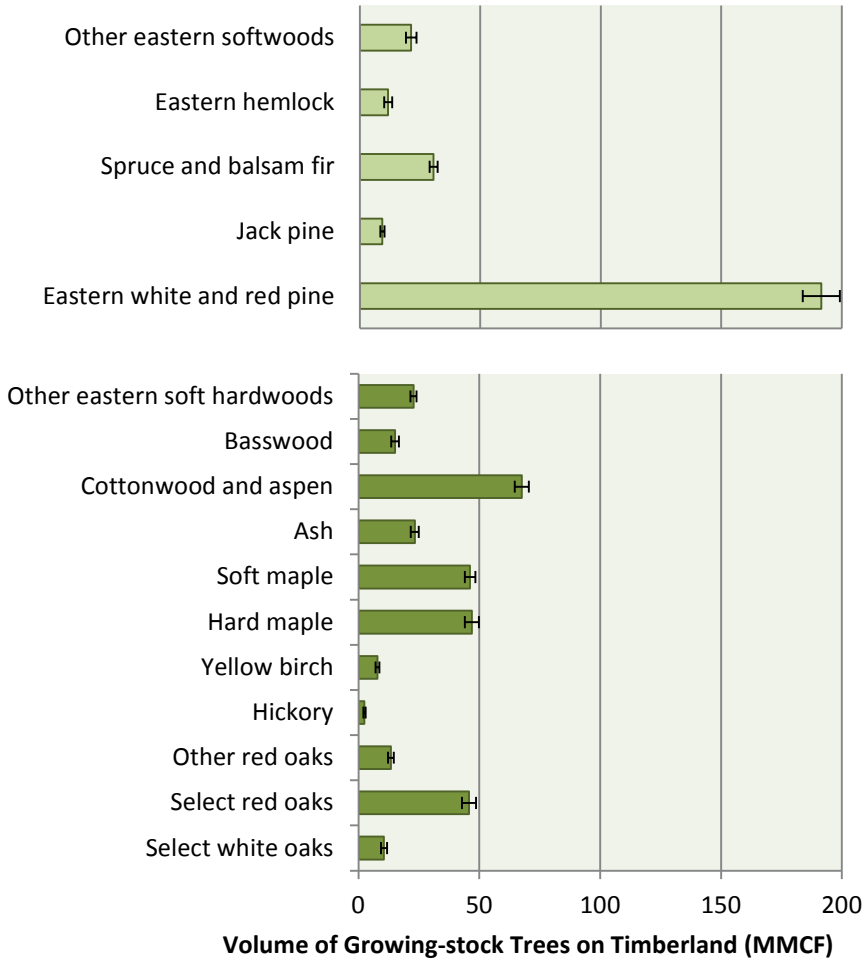


Figure 29. Volume of growing-stock trees on State Forest timberland: Softwoods (top hardwoods (bottom).

volume in the State Forests. Among hardwood species groups, cottonwood and aspen has the largest growing-stock volume (67.6 MMCF), followed by hard maple, soft maple, and select red oaks. The

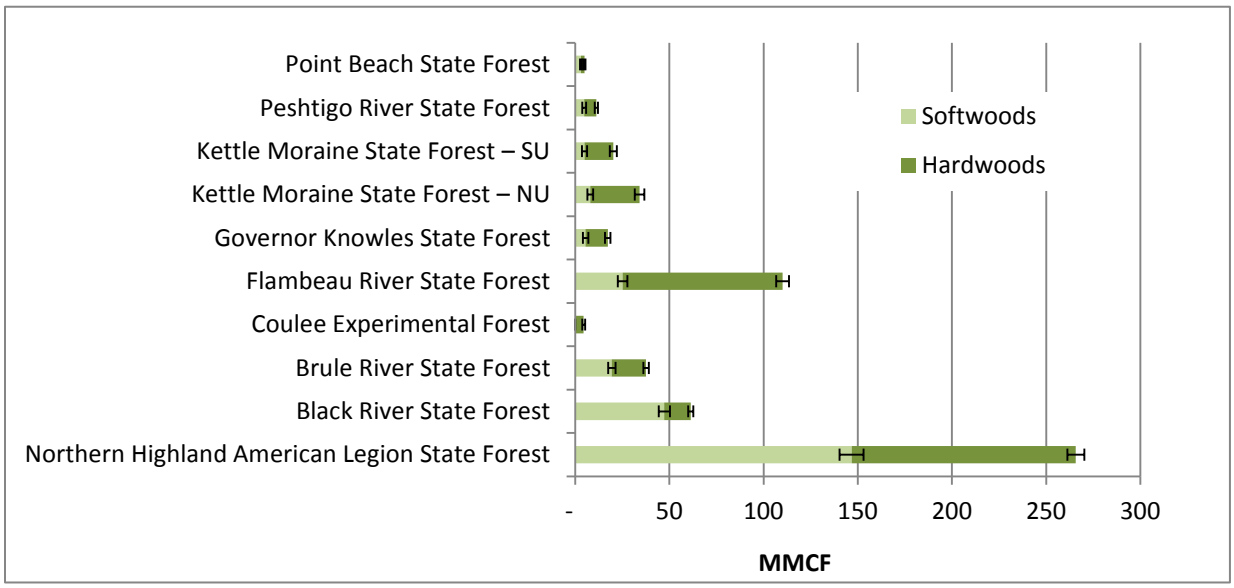


Figure 30. Volume of growing-stock trees on timberland by State Forest.

Northern Highland American Legion State Forest has the most growing-stock volume, with 265.4 MMCF. Flambeau River State Forest has 110.1 MMCF of growing stock volume, while the remaining State Forests have considerably smaller growing-stock volumes (Figure 30).

The ratio of hardwood to softwood volume is closer to one on the State Forests compared to the rest of the state. Hardwoods make up 53% of State Forest growing-stock volume but 73% of statewide (Perry et al 2012). The southern State Forests tend to have a much higher percentage of hardwoods than do the northern forests. However, the aspen and cottonwood forest type is a larger portion of State Forest growing-stock volume than it is on all timberland in the state as a whole. The percentage of select red oaks is higher on the State Forests (8.1%) compared to the state as a whole.

Compared to timberland on all Wisconsin ownerships, there is a smaller proportion of very large trees on the State Forests but, on average, trees are slightly larger. For instance, the most growing-stock volume on State Forests occurs in the 9-11 inch size class, but in the 7-9 inch size class on all state timberland (Figure 31).

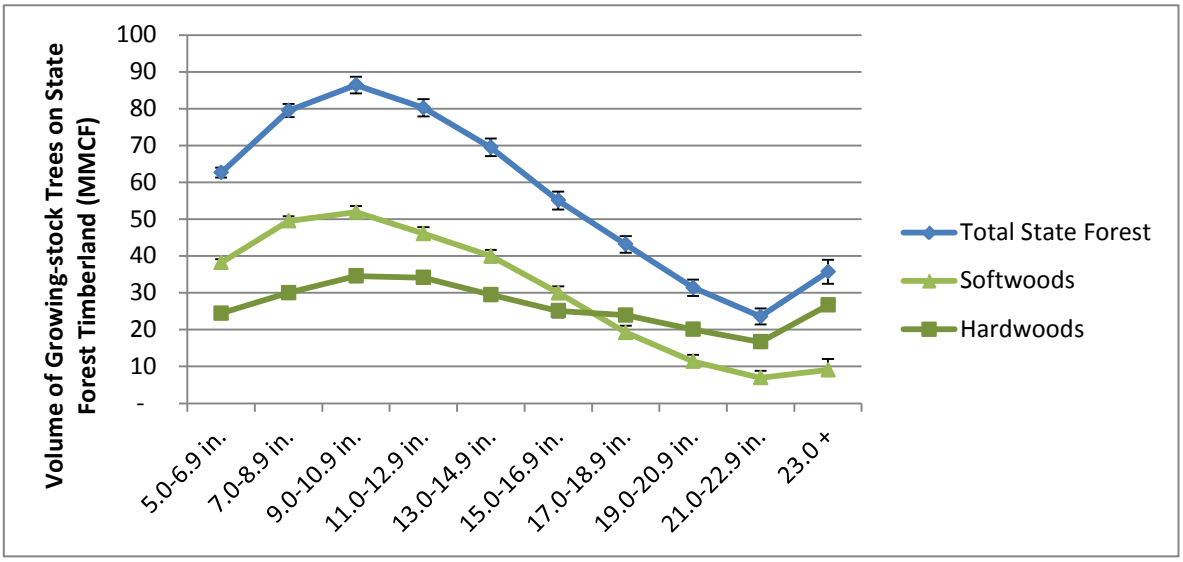


Figure 31. Volume of hardwood/softwood growing-stock trees on State Forest timberland by diameter class.

What this means

Stocking on the State Forests appears to be only slightly lower than in the state as a whole. In 2011, growing-stock volume on the State Forests made up 2.6% of the state total volume while acreage accounted for 2.7% of the total acreage in the state. Growing stock volume in softwood species is especially abundant in State Forests, and particularly in smaller diameter size classes. While some hardwood species of high commercial value, such as aspen and oak, appear to be well represented in State Forests, other hardwood species, including sugar maple and American basswood, are relatively rare. Analysis of growth, removal and mortality data in future inventories will help illustrate the trends with these species of concern.

Soft and hard maples (Joseph O'Brien, USDA Forest Service, Bugwood.org)

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Sawtimber Volume

Background

Sawtimber volume is an important indicator of the economic value of Wisconsin's State Forests. This resource not only provides direct economic benefit through sawtimber and veneer sales, but also supports wood-using secondary industries such as furniture and millwork manufacturing. Accurate measures of sawtimber quantity and quality help determine relative economic value of State Forest timber products.

What we found

Sawtimber volume on State Forest timberland in 2011 is estimated to be 1.86 billion board feet, representing about 2.9% of Wisconsin's sawtimber trees on all timberland. The eastern white and red pine

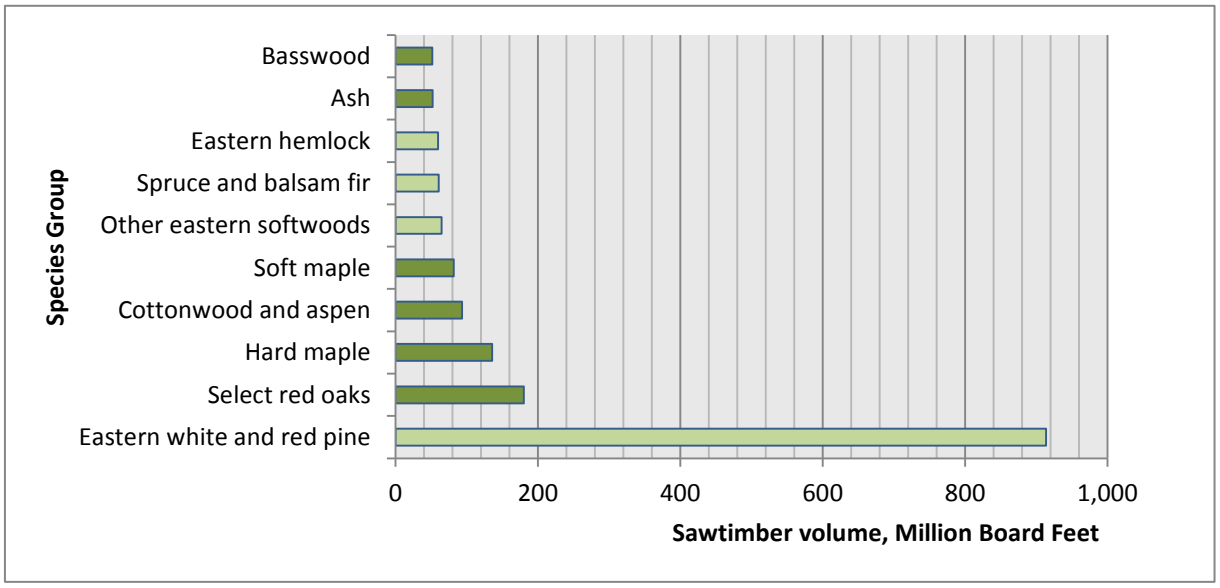


Figure 32. Volume of sawtimber by most common species groups on State Forest timberland by diameter class.

species group dominates sawtimber volume on State Forests, comprising roughly half of total sawtimber volume (Figure 32).

There is a higher proportion of softwood volume in sawtimber than in growing stock; comprising 60% of all sawtimber volume on State Forests. Half of all volume of sawtimber on the State Forests is located on the Northern Highland American Legion State Forest, with an estimated 926 million board feet. Seventy-one percent of this volume is made up of softwood species (Figure 33).

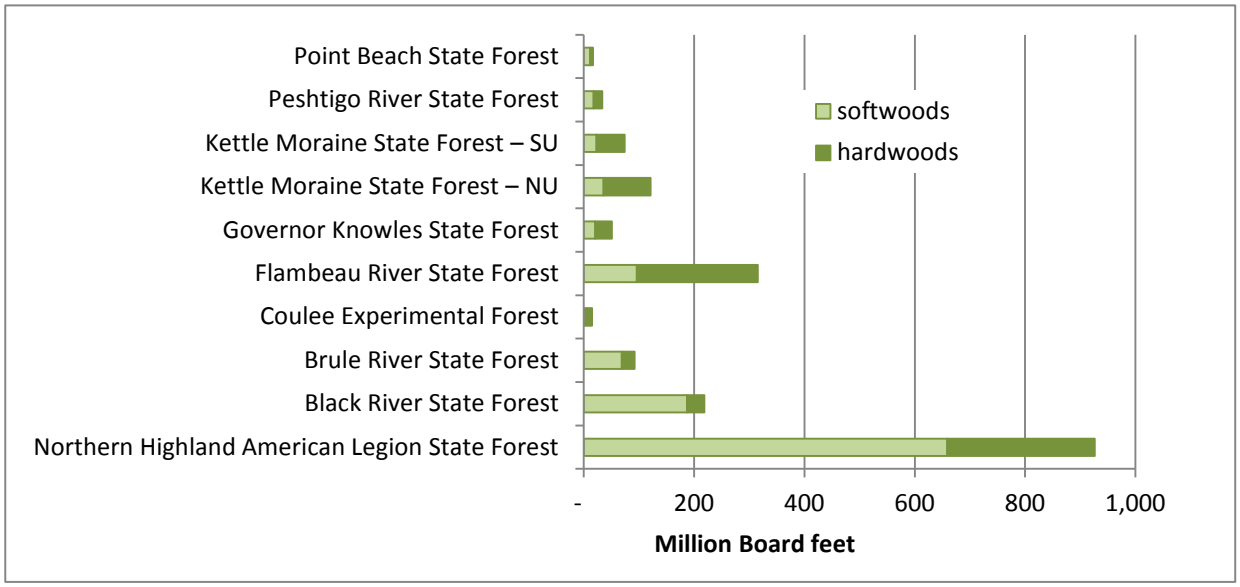


Figure 33. Volume of sawtimber by major species group and State Forest property.

Sawtimber quality directly impacts the economic benefits of sawtimber and veneer sales and also affects wood-using industries such as furniture and millwork manufacturing. Sawtimber quality is classified by grades 1 to 3; 1 represents the highest quality and 3 the lowest. In 2011, estimates of State Forest tree

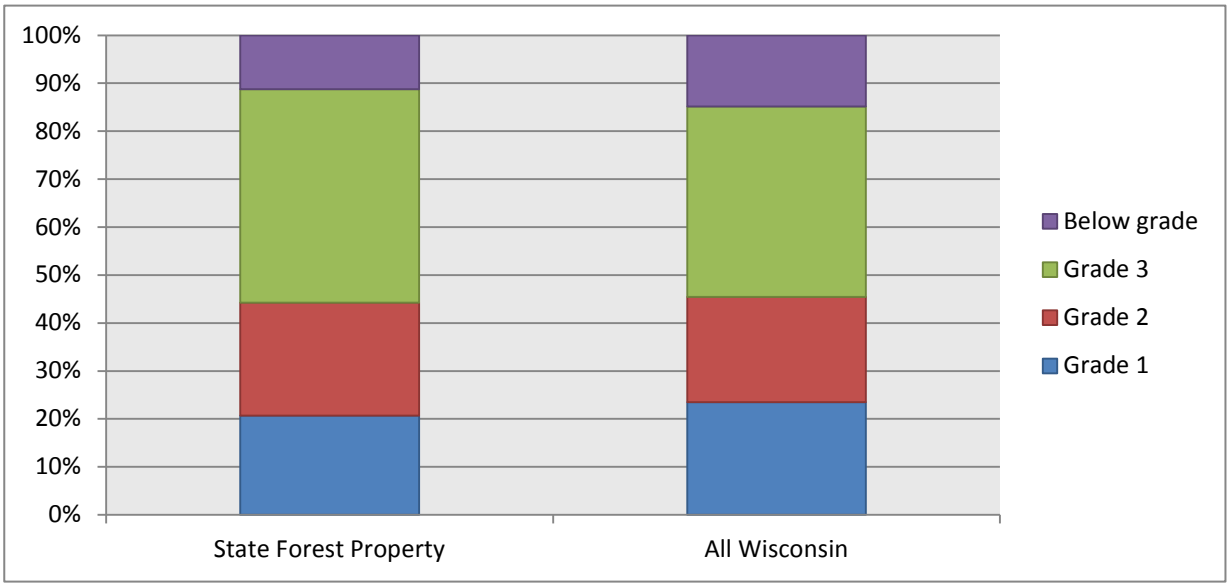


Figure 34. Distribution of sawtimber volume on timberland by grade,all Wisconsin versus State Forests.

grades showed less sawtimber volume in Grade 1 than statewide (Perry et al 2012), but also less that fell below grade standards (Figure 34). Distribution of sawtimber quality is variable among State Forests (Figure 35). The Flambeau River State Forest has the highest percentage of both Grade 1 and 2 sawtimber.

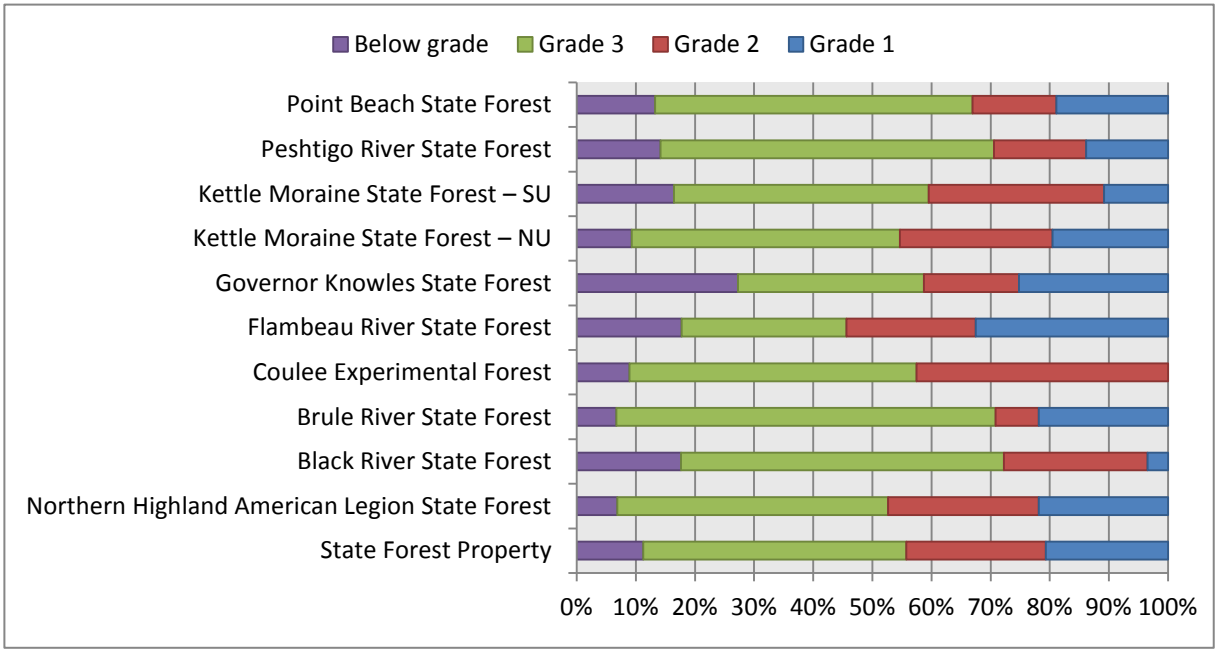


Figure 35. Distribution of sawtimber volume by grade on the State Forests.

What this means

Softwood species, especially red and white pine, comprise 60% of all sawtimber on State Forests, much higher than the proportion of these two species in statewide sawtimber volume (Perry et al 2012). This is probably due to the predominance of sandy soils on many of the State Forests. As with other metrics, analysis of growth, removal and mortality data going forward will show trends in sawtimber volume and quality on State Forests.

Timber Sales

Background

Poles and posts, USDA Forest Service NE, Bugwood.org

Wisconsin's State Forests regularly harvest timber products, by establishing commercial timber sales to achieve silvicultural objectives for specific stands and properties. These timber harvests produce the raw material which runs into a stream of income shared by the state, marketers, loggers, truckers and processors. The primary and secondary wood using industry encompasses sectors including, but not limited to, sawmills, pulp mills, veneer and plywood manufacturers as well as flooring, millwork and furniture producers. In 2010, the primary and secondary wood using industry in Wisconsin provided employment for more than 53,000 workers and generated a value of shipments worth $18.4 billion (Bureau of Labor Statistics, Quarterly Census of Employment and Wages, *www.bls.gov/cew/*). Reliable data on species, volumes and locations of timber harvests enhances management of State Forests.

What we found

Timber sales establishing harvests on Wisconsin's State Forests accounted for an estimated 5 percent of

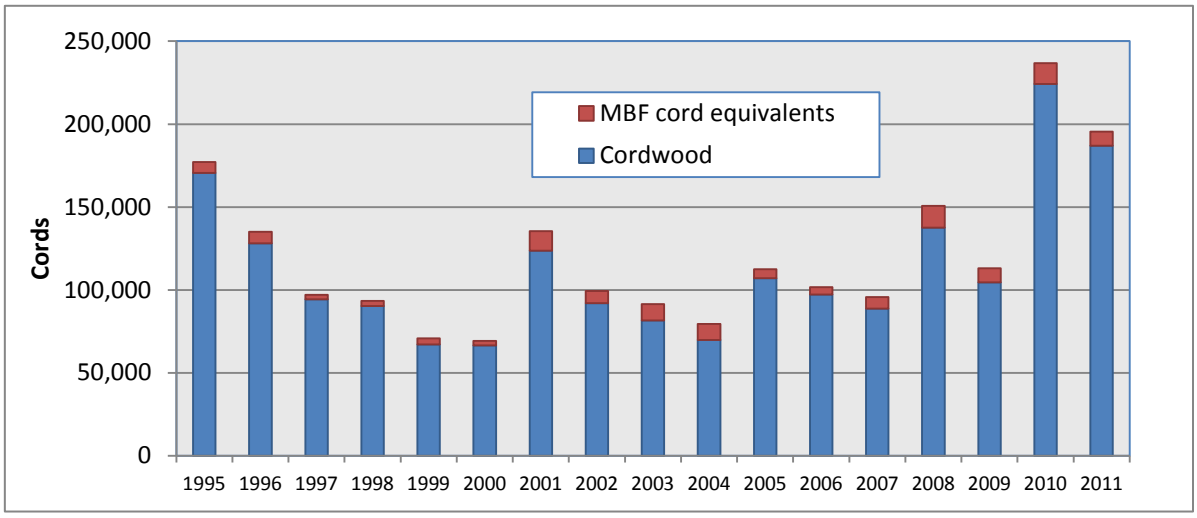


Figure 36. Volume (cords) of Wisconsin State Forest timber sales

all harvest volumes in the state in 2011. However, the portion of timber removals coming from State Forests has been increasing, especially in the period from 2008 to 2011, when harvest volumes on other forests in the state were declining (Figure 36). Harvests on State Forests occurred on increasingly more acres, yielding more volume than sales on federal lands for the first time in 2008, with that trend continuing through 2011.

Compared to harvests in Wisconsin on other forest ownership types, especially private lands, State Forests harvest a greater proportion of cordwood than sawtimber. In the period from 1995 to 2011, timber sale value has followed a general increasing trend, as stands especially of red and white pine reach more valuable sawtimber size and quality. Compared to timber harvest on other state-owned properties, State Forests tend to be much larger, and tend to yield higher stumpage rates (Table 15).

Table 15. Timber sales on Wisconsin's State Forests over time by number, acreage, value and volume.

Year	# of Sales	Acres	$ Stumpage	MBF	Cords	Total Cd. Equiv.
1995	111	10,364	$2,367,918	2,470	170,676	177,210
1996	89	8,114	$2,099,306	2,427	128,179	135,178
1997	77	5,979	$1,987,151	951	94,305	97,085
1998	66	5,806	$2,719,765	1,203	90,367	93,513
1999	67	4,383	$1,617,435	927	67,235	70,813
2000	77	4,912	$2,212,708	1,063	66,526	69,323
2001	120	8,336	$4,332,195	4,817	123,821	135,554
2002	113	6,318	$3,325,968	2,870	92,076	99,476
2003	74	5,274	$3,062,599	4,106	81,621	91,504
2004	63	4,437	$2,584,769	4,118	69,844	79,455
2005	91	5,925	$3,980,353	2,172	107,135	112,523
2006	65	5,918	$4,479,904	1,596	97,259	101,665
2007	63	5,590	$3,714,148	2,181	88,735	95,740
2008	97	9,130	$6,068,549	4,464	137,694	150,736
2009	82	6,422	$3,497,586	2,583	104,586	113,107
2010	105	12,628	$8,606,554	5,532	224,176	236,824
2011	98	10,974	$7,358,062	3,704	186,993	195,455

What this means

Though timber sales on State Forests produce a relatively small portion of harvests in the state overall, they are a much larger portion of sales locally. Mills located near State Forests are particularly dependent

upon harvests from their timber sales, since transportation costs are a limiting factor in marketing of roundwood (sawtimber and pulpwood). Further, due to proportionally higher production of softwoods from State Forests, they especially affect those wood-using industries which rely on softwood timber products.

Sustained timber sale levels on State Forests are critical to the profitability of forest products companies over a large area, especially those located close to them. This is particularly true for the larger State Forests such as the Northern Highland American Legion State Forest and the Flambeau River State Forest. Given the recent downturns in production of timber products from Wisconsin's timberland, the regular harvest schedules following Master Planning on State Forests provide a stable timber supply at a time when many private timber harvests might be postponed due to low timber stumpage prices. Publicly managed properties such as State Forests are not as reactive to such market forces, continuing to provide wood fiber that helps sustain primary and secondary wood processing firms through lean times. Subsequent years of WisCFI data will reveal trends in the relationship between growth and removals on State Forest lands and help determine what harvest levels are sustainable on these properties.

DATA SOURCES AND TECHNIQUES

Wisconsin Continuous Forest Inventory (WisCFI)

The WisCFI generally follows the methodology and techniques of the USDA Forest Service, Northern Research Station's Forest Inventory and Analysis (NRS-FIA) program annual inventory system. Information on the condition and status of all forest lands in Wisconsin has been obtained from the NRS-FIA for many years. Inventories of the State's forest resources were completed in 1936, 1956, 1968, 1983, 1996, and 2004. The 2009 inventory draft is completed and in the publication process (Cunningham and Moser 1938; Cunningham et al. 1939; Kotar et al. 1999; Perry et al. 2007; Schmidt 1998; Spencer and Thorne 1972; Spencer et al. 1988; Stone and Thorne 1961).

In the WisCFI, approximately one-fifth of all field plots are measured each year. The entire inventory is completed every 5 years. The WisCFI reports and analyzes results using a moving 5-year average. For example, WisCFI generates inventory results for 2007 through 2011.

Sampling Phases

The 2011 WisCFI was conducted in three phases. Phase 1 uses remotely sensed data to obtain initial plot land-cover observations and to stratify land area in the population of interest to increase the precision of estimates. In phase 2, field crews visit the physical locations of permanent field plots to measure traditional inventory variables such as tree species, diameter, and height. In phase 3, field crews visit a subset of phase 2 plots to obtain measurements for an additional suite of variables associated with forest and ecosystem health. The three phases of the WisCFI program as implemented in this inventory are discussed in greater detail in the sections that follow.

Phase 1

Aerial photographs, digital orthoquads (DOQs: digitally scanned aerial photograph), and satellite imagery are used for initial plot measurement via remotely sensed data and stratification. Phase 1 plot measurement consists of observations of conditions at the plot locations using aerial photographs or DOQs. Analysts determine a digitized geographic location for each field plot and a human interpreter assigns the plot a land cover/use. Lands satisfying WisCFI's definition of forest land include commercial timberland, some pastured land with trees, forest plantations, unproductive forested land, and reserved, noncommercial forested land. In addition, forest land requires minimum stocking levels, a 1-acre minimum area, and a minimum bole-to-bole width of 120 feet with continuous canopy. Forest land excludes wooded strips and windbreaks less than 120 feet wide and idle farmland or other previously non-

forest land that currently is below minimum stocking levels. All plot locations that could possibly contain accessible forest land are selected for further measurement via field crew visits in phase 2.

Phase 2

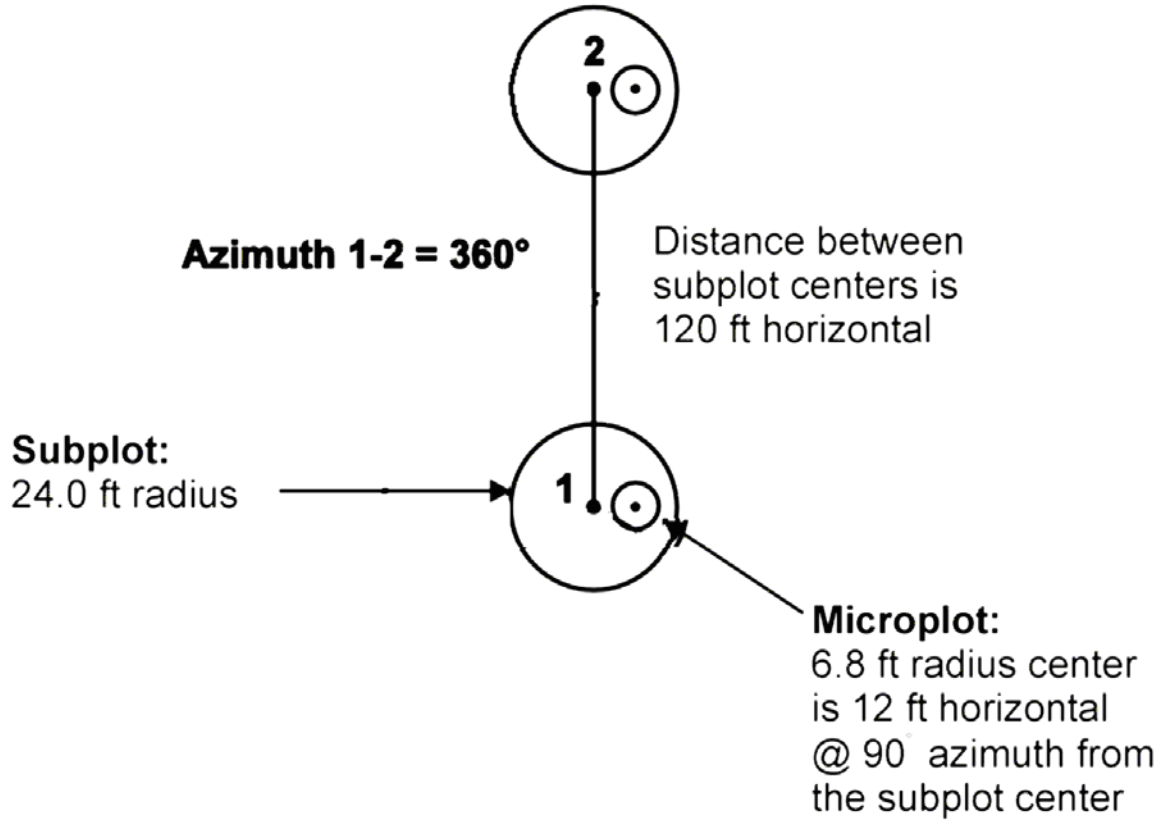
Phase 2 of the inventory consists of the measurement of the annual sample of WisCFI field plots. Current WisCFI precision standards for annual inventories require a sampling intensity of one plot for approximately every 200 acres. WisCFI has divided all State Forests in Wisconsin into non-overlapping hexagons, each of which contains 200 acres. This array of plots is considered an equal probability sample; its measurement in Wisconsin is funded by the State of Wisconsin. The total WisCFI sample of plots was systematically divided into five interpenetrating, non-overlapping subsamples or panels. Each year, the plots in a single panel are measured; panels are selected on a 5-year, rotating basis. For estimation purposes, the measurement of each panel of plots can be considered an independent systematic sample of all State Forests.

The overall phase 2 plot layout consists of two subplots (see Figure 1X). The center of subplot 2 is located 120 feet from the center of subplot 1. The azimuth to subplot 2 is 360 degrees, from the center of subplot 1. Trees with a d.b.h. of 5 inches or larger are measured on a 24-foot-radius (1/24-acre) circular subplot. All trees 1 to 4.9 inches in diameter are measured on a 6.8-foot-radius (1/300-acre) circular microplot located 12 feet east of the center of each of the two subplots. Seedlings [trees less than 1 inch d.b.h. and at least 6 inches tall (softwood species) or 12 inches tall (hardwood species)] are counted but not individually measured on this same microplot. Forest conditions on the two subplots are recorded.

Factors that differentiate forest conditions are changes in forest type, stand-size class, land use, ownership, and density. Each condition that occurs anywhere on any subplot is identified, described, and mapped if the area of the condition meets or exceeds 1 acre in size. Field crews determine the location of the geographic center of the center subplot using GPS receivers. They record condition-level observations that include land cover, forest type, stand origin, stand age, stand-size class, site-productivity class, history of forest disturbance, and land use for every condition (major land use or forest stand at least 1 acre in size) that occurs on the plot. They also record information on condition boundaries when multiple conditions are found on a plot. For each tree, field crews record a variety of observations and measurements, including condition, species, live/dead status, lean, diameter, height, crown ratio (percent of tree height represented by crown), crown class (dominant, codominant, suppressed), damage, and decay status. Office staff use statistical models based on field crew measurements to calculate values for additional variables, including individual-tree volume, per unit area estimates of number of trees, volume,

and biomass by plot, condition, species group, and live/dead status. Details of the data collection procedures used in phase 2 are available at http://dnr.wi.gov/topic/ForestPlanning/documents/WisCFIvolumeIversion2.pdf.

Figure 1X. Phase 2 plot design.



Phase 3

The third phase of the WisCFI focuses on forest health. The phase 3 sample consists of a 1:3 subset of the phase 2 plots with one phase 3 plot for about every 600 acres. Phase 3 measurements are obtained by field crews during the growing season and include an extended suite of ecological data: soil quality (erosion, compaction, and chemistry), crown density, vegetation diversity and structure, and down woody material. All phase 2 measurements are collected on each phase 3 plot at the same time as the phase 3 measurements. Additional information on the subplot designs and collection procedures used in phase 3 is available at: http://dnr.wi.gov/topic/ForestPlanning/documents/WisCFIvolumeIIversion2.pdf.

WisCFI plot location and access policy

Approximate locations of WisCFI plots are available to the public.

Requests for *exact* plot locations are subject to review and approval by the department's WisCFI Plot Access Committee. All requests for exact plot locations must be submitted in writing and are dependent on department approval.

Access to exact plot locations would only be granted under terms of a formal written agreement, which begins by submitting a Plot Location Request form [PDF]. You may download and print a Plot Location Request form [PDF], or contact Teague Prichard, State Forest specialist, at 608-264-8883 to obtain the form. If after review, the request is granted, a formal memorandum of understanding will be entered into by both parties.

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APPENDICES

Definition of WisCFI terms

Accessible Forest Land – Land that is within sampled area (the population of interest), is accessible and can safely be visited, and meets at least one of the two following criteria: (a) the condition is at least 10-percent stocked by trees (appendix 3) of any size or has been at least 10 percent stocked in the past. Additionally, the condition is not subject to nonforest use(s) that prevent normal tree regeneration and succession such as regular mowing, grazing, or recreation activities

Actual length – For trees with broken or missing tops. The actual length of the tree is recorded to the nearest 1.0 foot from ground level to the highest remaining portion of the tree still present and attached to the bole. If the top is intact, this item may be omitted. Forked trees should be treated the same as unforked trees.

Agricultural Land – Land managed for crops, pasture, or other agricultural use. Evidence includes geometric field and road patterns, fencing, and the traces produced by livestock or mechanized equipment. The area must be at least 1.0 acre in size and 120.0 feet. wide at the point of occurrence.

Artificial regeneration species – Indicates the predominant species that is planted or seeded in an artificially regenerated condition.

Average annual mortality of growing stock.--The average cubic foot volume of sound wood in growing-stock trees that died in one year. Average annual mortality is the average for the years between inventories.

Average annual mortality of sawtimber.--The average board foot volume of sound wood trees in sawtimber *t*rees that died in one year. Average annual mortality is the average for the years between inventories.

Average annual removals from growing stock.--The avera*g*e net *g*rowing-stock volume in growing-stock trees removed annually for roundwood forest products, in addition to the volume of log*g*ing residues, and the volume of other removals. Average annual removals of growing stock are the avera*g*e for the years between inventories.

Average annual removals from sawtimber.--The average net board foot sawtimber volume of live sawtimber trees removed annually for roundwood forest products, in addition to the volume of logging residues, and the volume of other removals. Average annual removals of are the average for the years between inventories and are based on information obtained from remeasurement plots.

Average net annual growth of growing stock --The annual change in cubic foot volume of sound wood in live sawtimber and poletimber trees, and the total volume of trees entering these classes through ingrowth, less volume losses resulting from natural causes. Average net annual growing stock is the average for the years between inventories.

Average net annual growth of sawtimber --The annual change in the board foot volume of live sawtimber trees, and the total volume of trees reaching sawtimber size, less volume losses resulting from natural causes. Average net annual growth of sawtimber is the average for the years between inventories.

Basal area.--The area in square feet of the cross section at breast height of a single tree. When the basal areas of all live trees in a stand are summed, the result is usually expressed as square feet of basal area per acre.

Biomass.--The aboveground volume of all live trees (including bark but excluding foliage) reported in green tons (i. e., green weight).

Biomass has four components:

Bole.--Biomass of a tree from 1 foot above the ground to a 4-inch top outside bark.

Tops and limbs.--Total biomass of tree from a 1-foot stump minus the bole.

I-to 5-inch trees.---Total aboveground biomass of a tree from 1 to 5 inches in diameter at breast height.

Sturnp. ---Biomass of a tree 5 inches d. b. h. and larger from the *ground* to a height of 1 foot.

Bogs – Peat lands usually lacking an overlaying layer of mineral soils. They occur primarily in formerly glaciated areas of the northeastern U.S., the north-central states, and Canada and often develop in deep glaciated lakes. Bogs are characterized by evergreen trees and shrubs and are often covered with sphagnum moss.

Bolt.--A short log no more than 8 feet long, to be sawn for lumber, peeled or sliced for veneer, shaved for excelsior, or converted into shingles, cooperage stock, dimension stock, blocks, blanks, etc.

Boundary – The intersection of two or more conditions on a subplot or microplot. Each boundary is described by recording the azimuth and horizontal distance from the subplot or microplot center to the left and right points of where the boundary intersects the perimeter of the subplot or microplot. An azimuth and distance to a corner point may also be described, if one exists. If multiple boundaries exist at a subplot, they are recorded in the order of their occurrence on the subplot, starting from north and proceeding around the compass.

Census Water – Rivers and streams that are more than 200 feet wide and bodies of water that are greater than 4.5 acres in size.

Commercial species.--Tree species presently or prospectively suitable for industrial wood products. (Note: Excludes species of typically small size, poor form, or inferior quality such as hophornbeam, Osage-orange, and redbud.)

Condition class – The combination of discrete landscape and forest attributes that identify and define different strata on the plot. Examples of such attributes include condition class status, forest type, stand origin, stand size, reserve status and stand density.

Cord.--One standard cord is 128 cubic feet of stacked wood, including bark and air space. Cubic feet can be converted to solid wood standard cords by dividing by 79.

Cropland.--Land under cultivation within the last 24 months; including cropland harvested, crop failures, cultivated summer fallow, idle cropland used only for pasture, orchards, active Christmas tree plantations indicated by annual shearing, nurseries, and land in soil improvement crops, but excluding land cultivated in developing improved pasture.

Crown class – A classification of trees based on dominance in relation to adjacent trees within the stand as indicated by crown development and the amount of sunlight received from above and sides.

Cull.--Portions of a tree that are unusable for industrial wood products because of rot, form, or other defect.

Current annual net growth of growing stock.--The annual change in volume of sound wood in live sawtimber and poletimber trees, and the total volume of trees entering these classes through ingrowth, less volume losses resulting from natural causes, reported for a single year. Current growth is based on an estimate of the current annual increment of each growing-stock tree in the inventory.

Current annual net growth of sawtimber.--The annual change in the volume of live sawtimber trees, and the total volume of trees reaching sawtimber size, less volume losses resulting from natural causes, reported for a single year. Current growth is based on an estimate of the current annual increment of each growing-stock tree in the inventory.

Current annual removals from growing stock.--The current net growing-stock volume in growing-stock trees removed annually for roundwood forest products, in addition to the volume of logging residues, and the volume of other removals. Current annual removals of growing stock are reported for a single year; they are based on a survey of primary wood processing mills to determine removals

for products and on information from remeasurement plots (see Survey Procedures in Appendix) to determine removals due to land use change.

Current annual removals from sawtimber.--The current net board foot sawtimber volume of live sawtimber trees removed annually for roundwood forest products, in addition to volume of other removals. Current annual removals of sawtimber are reported for a single year; they are based on a survey of primary wood processing mills to determine removals for products and on information from remeasurement plots (see Survey Procedures in Appendix) to determine removals due to land use change.

Diameter at Breast Height (DBH).--The outside bark diameter of a tree at breast height (4.5 feet above the ground), on the uphill side of the tree.

Diameter Class.--A classification of trees based on diameter outside bark, measured at breast height 4.5 feet above the ground. (Note d.b.h, is the *c*ommon abbreviation for diameter at breast height.) Two-inch diameter classes are commonly used in Forest Inventory and Analysis, with the even inch the approximate midpoint for a class. For example, the 6-inch class includes trees 5.0 through 6.9 inches d.b.h.

Forest land.--Land at least 16.7 percent stocked by forest trees of any size, or formerly having had such tree cover, and not currently developed for nonforest use. (Note: Stocking is measured by comparing specified standards with basal area and /or number of trees, age or size, and spacing.) The minimum area for classification of forest land is 1 acre. Roadside, streamside, and shelterbelt strips of timber must have a crown width of at least 120 feet to qualify as forest land. Unimproved roads and trails, streams or other bodies of water, or clearings in forest areas shall be classed as forest if less than 120 feet wide.

Forest Trees – Plants having a well-developed, woody stem and usually more than 12 feet in height at maturity.

Forest type-FIA. -- A classification of forest land based on the species forming a plurality of live tree stocking. The associated species for each forest type are based on net volume of growing stock and all live biomass by species group. Major forest types in the State are:

Jack pine.--Forests in which jack pine comprises a plurality of the stocking. Species commonly associated with the jack pine forest type in Wisconsin include red pine, red oaks, aspen, and eastern white pine.

Red pine.--Forests in which red pine comprises a plurality of the stocking. Species commonly associated with the red pine forest type in Wisconsin include eastern white pine, jack pine, and aspen.

Eastern white pine.--Forests in which eastern white pine comprises a plurality of the stocking. Species commonly associated with the eastern white pine forest type in Wisconsin include red pine, aspen, red maple, paper birch, and red oak.

Balsam fir.--Forests in which balsam fir and white spruce comprise a plurality of stocking, with balsam fir tile most common. Species commonly associated with the balsam fir forest type in Wisconsin include white spruce, aspen, northern white-cedar, tamarack, paper birch, red maple, black spruce, and eastern white pine.

White spruce.--Forests in which white spruce and balsam fir comprise a plurality of the stocking, with white spruce the most common. Species commonly associated with the white spruce forest type in Wisconsin include aspen, paper birch, balsam fir, eastern white pine, red maple, and northern white-cedar.

Black spruce.--Forests in which swamp conifers comprise a plurality of the stocking, with black spruce the most common. Species commonly associated with the black spruce forest type in Wisconsin include tamarack, balsam fir, eastern white pine, northern white-cedar, aspen, jack pine, and paper birch.

Northern *white-cedar.*--Forests in which swamp conifers comprise a plurality of the stocking, with northern white-cedar the most common. Species commonly associated with the northern white-cedar forest type in Wisconsin include balsam fir, paper birch, black spruce, tamarack, black ash, red maple, and aspen.

Tamarack.--Forests in which swamp conifers comprise a plurality of the stocking, with tamarack the most common. Species commonly associated with the tamarack forest type in Wisconsin include northern white-cedar, black spruce, red maple, white pine, balsam fir, and paper birch.

Oak-hickory.--Forests in which northern red oak, white oak, bur oak, or hickories, singly or in combination, comprise a plurality of the stocking. Species commonly associated with the oak-hickory forest type in Wisconsin include red maple, aspen, and black cherry.

Elm-ash-soft maple.--Forests in which lowland elm, ash, red maple, silver maple, and cottonwood, singly or in combination, comprise a plurality of the stocking. Species commonly associated with the elm-ash-soft maple forest type in Wisconsin include northern white-cedar, aspen, cottonwood, and balsam fir.

Maple-beech-birch.--Forests in which sugar maple, yellow birch, American elm, and red maple, singly or in combination, comprise a plurality of the stocking. Species commonly associated with the maple-

beech-birch forest type in Wisconsin include American basswood, eastern hemlock, green and white ash, aspen, black cherry, and select red oaks.

Aspen.--Forests in which quaking aspen or bigtooth aspen, singly or in combination, comprise a plurality of the stocking. Species commonly associated with the aspen forest type in Wisconsin include red maple, paper birch, balsam fir, and select red oaks.

Paper birch.--Forests in which paper birch comprises a plurality of the stocking. Species commonly associated with the paper birch forest type in Wisconsin include aspen, red maple, balsam fir, northern white-cedar, sugar maple, and balsam poplar.

Balsam poplar.--*Forests* in which balsam poplar comprises a plurality of the stocking. Species commonly associated with the balsam poplar forest type in Wisconsin include balsam fir, aspen, northern white-cedar, paper birch, black ash, and white spruce.

Forest type-WisCFI. - A tract of forest land characterized by the predominance of one or more key species which make up 50 percent or more of the basal area of saw-timber and pole-timber stands, or of the number of trees in seedling and sapling stands. Forest land less than 10 percent stocked with commercial tree species is classified as upland brush, grass or lowland brush.

Aspen--Aspen comprises 50% or more of the basal area in saw-timber and pole-timber stands, or 50% or more of the stems in sapling and seedling stands.

Bottomland hardwoods --Any combination of silver maple, green ash, swamp white oak, American elm, river birch, and cottonwood comprises 50% or more of the basal area in saw-timber and pole-timber stands, or 50% or more of the stems in sapling and seedling stands. Hardwood dominated forests occurring on floodplains and some terraces.

White birch --White Birch comprises 50% or more of the basal area in saw-timber and pole-timber stands, or 50% or more of the stems in sapling and seedling stands.

White cedar --White cedar comprises 50% or more of the basal area in saw-timber and pole-timber stands, or 50% or more of the stems in sapling and seedling stands. In mixed swamp conifer stands, white cedar is predominant.

Central hardwoods --Any combination of oaks, hickories, elms, black cherry, hackberry, red maple, white ash, green ash, basswood, and sugar maple, which does not satisfy the defining criteria for NH, MR, or O cover types. The CH type occurs only on uplands within and south of the Tension Zone (southern Wisconsin).

Balsam Fir --Balsam fir comprises 50% or more of the basal area in saw-timber and pole-timber stands, or 50% or more of the stems in sapling and seedling stands. In mixed swamp conifer stands, balsam fir is predominant.

Hemlock --Hemlock comprises 50% or more of the basal area in saw-timber and pole-timber stands, or 50% or more of the stems in sapling and seedling stands.

Miscellaneous Conifers --Conifer forests dominated by uncommon or exotic species; e.g. Eastern red cedar, Scotch pine, Norway spruce, European Larch.

Miscellaneous Deciduous --Hardwood forests dominated by uncommon or exotic species; e.g. box elder, honey locust, black locust, Norway maple.

Red Maple --Red Maple comprises 50% or more of the basal area in saw-timber and pole-timber stands, or 50% or more of the stems in sapling and seedling stands. If soil is poorly drained, then swamp hardwood.

Northern hardwoods --Any combination of sugar maple, beech, basswood, white ash, and yellow birch comprises 50% or more of the basal area in saw-timber and pole-timber stands, or 50% or more of the stems in sapling and seedling stands.

Oak --Oak comprises 50% or more of the basal area in saw-timber and pole-timber stands, or 50% or more of the stems in saplings and seedling stands.

Scrub oak --More than 50% of the basal area in saw-timber and pole-timber stands, or 50% or more of the stems in sapling and seedling stands is comprised of oak with site indices $\leq$50. Typical forest products include only fuelwood and fiber.

Red pine --Red pine comprises 50% or more of the basal area in saw-timber and pole-timber stands, or 50% or more of the stems in sapling and seedling stands. In mixed pine stands, red pine is predominant.

White pine --White pine comprises 50% or more of the basal area in saw-timber and pole-timber stands, or 50% or more of the stems in sapling and seedling stands. In mixed pine stands, white pine is predominant.

Jack pine --Jack pine comprises 50% or more of the basal area in saw-timber and pole-timber stands, or 50% or more of the stems in sapling and seedling stands. In mixed pine stands, jack pine is predominant.

Black spruce --Black spruce comprises 50% or more of the basal area in saw-timber and pole-timber stands, or 50% or more of the stems in sapling and seedling stands. In mixed swamp conifer stands, black spruce is predominant.

Swamp hardwoods --Any combination of black ash, green ash, red maple, silver maple, swamp white oak, and American elm that comprises 50% or more of the basal area in saw-timber and pole-timber stands, or 50% or more of the stems in sapling and seedling stands. This type occurs on wetlands characterized by periodic inundation (fluctuating water table near or above the soil surface) and nearly permanent subsurface water flow.

White Spruce --White spruce comprises 50% or more of the basal area in saw-timber and pole-timber stands, or 50% or more of the stems in sapling and seedling stands.

Tamarack --Tamarack comprises 50% or more of the basal area in saw-timber and pole-timber stands, or 50% or more of the stems in sapling and seedling stands. In mixed swamp conifer stands, tamarack is predominant.

Black Walnut --Black walnut comprises 50% or more of the basal area in saw-timber and pole-timber stands, or 50% or more of the stems in sapling and seedling stands.

Growing-stock tree.--A live timberland tree of commercial species that meets specified standards of size, quality, and merchantability. (Note: Excludes rough, rotten, and dead trees.)

Growing-stock volume.--Net volume in cubic feet of growing-stock trees 5.0 inches d.b.h. and over, from 1 foot above the ground to a minimum 4.0- inch top diameter outside bark of the central stem or to the point where the central stem breaks into limbs.

Hard hardwoods.--Hardwood species with an average specific gravity greater than 0.50 such as oaks, hard maple, hickories, and ash.

Hardwoods --Dicotyledonous trees, usually broadleaved and deciduous.

Industrial wood.--All roundwood products except residential fuelwood.

Land.--*A. Bureau of the Census*. Dry land and land temporarily or partly covered by water such as marshes, swamps, and river flood plains (omitting tidal flats below mean high tide); streams, sloughs, estuaries, and canals less than one-eighth of a statute mile wide; and lakes, reservoirs, and ponds less than 40 acres in area.

B. Forest Inventory and Analysis. The same as the Bureau of the Census, except minimum width of streams, etc., is I20 feet and minimum size of lakes, etc., is 1 acre.

Live trees.--Growing-stock, rough, and rotten trees 1.0 inch d. b. h, and larger.

Log grade.--A log classification based on external characteristics as indicators of quality or value. Log grade was assigned to a sample of softwood sawtimber trees throughout the State during the 1996 inventory. Also see Tree grade.

Logging residue.--The unused portions of cut trees, plus unused trees killed by logging

Marsh.--Nonforest land that characteristically supports low, generally herbaceous or shrubby vegetation, and that is intermittently covered with water.

Merchantable.--Refers to a pulpwood or saw-log section that meets pulpwood or saw-log specifications, respectively.

Merchantable Top – The point on the bole of trees above which merchantable material cannot be produced. Merchantable top is 4.0 inches for all other species.

Microplot – A circular, fixed-radius plot with a radius of 6.8 feet that is used to sample trees less than 5.0 inches at DBH, as well as other vegetation.

Net volume.--Gross volume less deductions for rot, sweep, or other defect affecting use for timber products.

Non-census Water – Bodies of water from 1 to 4.5 acres in size and water courses from 30 feet to 200 feet in width.

Noncommercial species.--Tree species of typically small size, poor form, or inferior quality that normally do not develop into trees suitable for industrial wood products.

Nonforest land.--Land that has never supported forests, and land formerly forested where use for timber management is precluded by development for other uses. (Note: Includes areas used for crops, active Christmas tree plantations as indicated by annual shearing, orchards, nurseries, improved pasture, residential areas, city parks, ira- proved roads of any width and adjoining clearings, powerline clearings of any width, and 1-to 40-acre areas of water classified by the Bureau of the Census as land.) If intermingled in forest areas, unimproved roads and nonforest strips must be more than 120 feet wide and more than 1 acre in area to qualify as nonforest land.

a. Nonforest land without trees.--Nonforest land with no live trees present.

b. Nonforest land with trees.--Nonforest land with one or more trees per acre at least 5 inches d.b.h.

Nonstocked land.--Timberland less than 16.7 percent stocked with all live trees.

Other forest land.--Forest land not capable of producing 20 cubic feet per acre per year of industrial wood crops under natural conditions and not associated with urban or rural development. Many of these sites contain tree species that are not currently utilized for industrial wood production or trees of poor form, small size, or inferior quality that are unfit for most industrial products. Unproductivity may be the result of adverse site conditions such as sterile soil, dry climate, poor drainage, high elevation, and rockiness. This land is not withdrawn from timber utilization.

Other removals.--Growing-stock trees removed but not utilized for products, or trees left standing but "removed" from the timber land classification by land use change. Examples are removals from cultural operations such as timber stand improvement work and land clearing, and the standing volume on land classified originally as timberland but later designated as reserved from timber harvesting {such as a newly established State park).

Ownership size class.--The amount of timberland owned by one owner, regardless of the number of parcels.

Pasture.--Land presently used for grazing or under cultivation to develop grazing.

Phase 1 (P1) – activities done as part of remote-sensing and/or aerial photography.

Phase 2 (P2) – activities done on the network of ground plots formerly known as WisCFI plots.

Phase 3 (P3) – activities done on a subset of Phase 2 plots. Additional ecological indicator information is collected from Phase 3 plots.

Physiographic class.--A measure of soil and water conditions that affect tree growth on a site. The physiographic classes are:

Xeric sites.--Very dry soils where excessive drainage seriously limits both growth and species occurrence. Example: sandy jack pine plains.

Xeromesic sites.--Moderately dry soils where excessive drainage limits growth and species occurrence to some extent. Ex ample: dry oak ridge.

Mesic sites.--Deep, well-drained soils. Growth and species occurrence are limited only by climate. Example: well-drained terraces of loamy soil.

Hydromesic sites.--Moderately wet soils where insufficient drainage or infrequent flooding limits growth and species occurrence to some extent. Example: moderately drained bottomland hardwood sites.

Hydric sites.--Very wet sites where excess water seriously limits both growth and species occurrence. Example: frequently flooded river bottoms and black spruce swamps.

Plant byproducts.--Plant residues used for products such as mulch, pulp chips, and fuelwood.

Plantation.--An artificially reforested area sufficiently productive to qualify as timberland. The planted species is not necessarily predominant. Christmas tree plantations, which are considered cropland, are not included.

Plant residues.--Wood and bark materials generated at manufacturing plants during production of other products.

Plot – A cluster of subplots that samples approximately 1/6 acre. The subplots are established so that subplot 1 is centered within the sample and the centers of subplots 2, 3,and 4 are located 120.0 feet from the center of subplot 1 at azimuths of 360, 120, and 240 degrees, respectively. Each subplot has an associated microplot.

Poletimber stand.--(See Stand-size class.)

Poletimber tree.--A live tree of commercial species at least 5.0 inches d. b. h., but smaller than sawtimber size.

Potential productivity class.--A classification of forest land in terms of inherent capacity to grow crops of industrial wood. The class identifies the potential growth in merchantable cubic feet/ acre/ year at culmination of mean annual increment of fully stocked natural stands.

Reserved forest land.--Forest land withdrawn from timber utilization through statute, administrative regulation, or designation. Note: historically, Christmas tree plantations were classified as reserved forest land. However, Christmas tree plantations are now classified as cropland.

Rotten tree.--Live trees of commercial species that do not contain at least one 12-foot saw-log or two saw logs 8 feet or longer, now or prospectively, and/ or do not meet regional specifications for freedom from defect primarily because of rot; that is, when more than 50 percent of the cull volume in a tree is rotten.

Rough tree.--(a) Live trees of commercial species that do not contain at least one merchantable 12-foot saw log or two saw-logs 8 feet or longer, now or prospectively, and/ or do not meet regional specifications for freedom from defect primarily because of roughness or poor form, and (b) all live trees of noncommercial species.

Roundwood products.--Logs, bolts, or other round sections (including chips from roundwood} cut from trees for industrial or consumer uses. (Note: includes saw logs, veneer logs, and bolts; cooperage logs and bolts; pulpwood; fuelwood; pilings; poles; posts; hewn ties; mine timbers; and various other round, spilt, or hewn products.)

Salvable dead tree.--A standing or down dead tree considered merchantable by regional standards.

Sapling.--A live tree between 1.0 and 5.0 inches d.b.h.

Sapling-seedling stand.--(See Stand-size class.)

Saw log.--A log meeting minimum standards of diameter, length, and defect, including logs at least 8 feet long, sound and straight and with a minimum diameter outside bark(d. o. b.) for softwoods of 7.0 inches (9.0 inches for hardwoods) or other combinations of size and defect specified by regional standards.

Saw-log portion.--That part of the bole of sawtimber trees between the stump and the saw-log top.

Saw-log top.--The point on the bole of sawtimber trees above which a saw log cannot be produced. The minimum saw-log top is7.0 inches d. o. b, for softwoods and 9.0 inches d. o. b, for hardwoods.

Sawtimber stand.-- (See Stand-size class.)

Sawtimber tree.--A live tree of commercial species containing at least a 12-foot saw log or two noncontiguous saw logs 8 feet or longer, and meeting regional specifications for freedom from defect. Softwoods must be at least 9.0 inches d. b. h. Hardwoods must be at least 11.0 inches d.b.h.

Sawtimber volume.--Net volume of the saw-log portion of live sawtimber in board feet, International 1/ 4-inch rule (unless specified otherwise), from stump to a minimum 7.0 inches top d. o. b, for softwoods and a minimum 9.0 inches top d. o. b, for hardwoods.

Seedling.--A live tree less than 1.0 inch d. b. h, that is expected to survive. Only softwood seedlings more than 6 inches tall and hardwood seedlings more than 1 foot tall are counted.

Short-log (rough tree).--A sawtimber-size tree of commercial species that contains at least one merchantable 8- to 11-foot saw log but not a 12-foot saw log.

Shrub.--A woody, perennial plant differing from a perennial herb in its persistent and woody stem(s) and less definitely from a tree in its lower stature and/or the general absence of a well-defined main stem. For this report, shrubs were separated somewhat arbitrarily into tall and low shrubs as follows:

Tall shrubs.--Normally taller than 1.6 to 3.2 feet (0.5 to 1.0 meter).

Low shrubs.--Normally shorter than 1.6 to 3.2 feet (0.5 to 1.0 meter). (Woody perennial vines, such as grape, were included with low shrubs.)

Shrub and tree seedling biomass.--The total aboveground weight of trees less than 1.0 inch in diameter and all shrubs.

Site index.--An expression of forest site quality based on the height of a free-growing dominant or codominant tree of a representative species in the forest type at age 50.

Soft hardwoods.--Hardwood species with an average specific gravity less than 0.50, such as cottonwood, red maple, American basswood, and willow.

Softwoods.--*Coniferous* trees, usually evergreen, having needles or scale-like leaves.

Stand.--A group of trees on a minimum of 1 acre of forest land that is stocked by forest trees of any size.

Stand-age class.--A classification based on age of the main stand. Main stand refers to trees of the dominant forest type and stand-size class.

Stand density – A stand descriptor that indicates the relative tree density of a condition class. The classification is based on the number of stems/unit area, basal area, tree cover, or stocking of all live trees in the condition which are not overtopped, compared to any previously defined condition class tree density.

Stand-size class.--A classification of stocked (see Stocking) forest land based on the size class of live trees on the area; that is, sawtimber, poletimber, or seedlings and saplings.

Sawtimber stands.--Stands with half or more of live tree stocking in sawtimber or poletimber trees, and with sawtimber stocking at least equal to poletimber stocking.

PoIetimber stands.--Stands with half or more of live tree stocking in poletimber and/or sawtimber *trees,* and with poletimber stocking exceeding that of sawtimber.

Sapling-seedling stands.--Stands with more than half of the live tree stocking in saplings and/or seedlings.

Stocking.--The degree of occupancy of land by live trees, measured by basal area and/or the number of trees in a stand by size or age and spacing, compared to the basal area and/ or number of trees required to fully utilize the growth potential of the land; that is, the stocking standard. A stocking percent of 100 indicates full utilization of the site and is equivalent to 80 square feet of basal area per acre in trees 5.0 inches d. b. h. and larger. In a stand of trees less than 5 inches d. b. h., a stocking percent of 100 would indicate that the present number of trees is sufficient to produce 80 square feet of basal area per acre when the trees reach 5 inches d. b. h.

Stands are grouped into the following stocking classes:

Overstocked stands.--Stands in which stocking of live trees is 133.0 percent or more.

Fully stocked stands.--Stands in which stocking of live trees is from 100.0 to 132.9 percent.

Medium stocked stands.--Stands in which stocking of live trees is from 60.0 to 99.9 percent.

Poorly stocked stands.--Stands in which stocking of live trees is from 16.7 to 59.9 percent.

Nonstocked areas.--Timberland on which stocking of live trees is less than 16.7 percent.

Subplot – A circular, fixed-area plot with a radius of 24.0 feet. Each subplot represents ¼ of the fixed plot sample unit.

Swamps – Wet areas dominated by woody shrubs and trees, some with hardwoods such as red maple and ashes and others with softwoods like cedar and spruce. Willows, alders, shrubby dogwoods, and buttonbush dominate shrub swamps. Some shrub swamps are permanent, while others slowly transform to forested swamps.

Timber products output.--All timber products cut from roundwood and byproducts of wood manufacturing plants. Roundwood products include logs, bolts, or other round sections cut from growing-stock trees, cull trees, salvable dead trees, trees on nonforest land, noncommercial species, sapling-size trees, and limbwood. Byproducts from primary manufacturing plants include slabs, edging, trimmings, miscuts, sawdust, shavings, veneer cores and clippings, and screenings of pulpmills that are used as pulpwood chips or other products.

Timberland.--Forest land that is producing, or is capable of producing, more than 20 cubic feet per acre per year of industrial wood crops under natural conditions, that is not withdrawn from timber utilization, and that is not associated with urban or rural development. Currently inaccessible and inoperable areas are included. (Timberland was formerly called commercial forest land.)

Transition Zone – An area where a distinct boundary between two or more different conditions cannot be determined.

Tree.--A woody plant usually having one or more erect perennial stems, a stem diameter at breast height of at least 3 inches, a more or less definitely formed crown of foliage, and a height of at least 13 feet at maturity.

Tree biomass.--The total aboveground weight (including the bark but excluding the foliage) of all trees from 1 to 5 inches in d. b. h., and the total aboveground weight (including the bark but excluding the foliage) from a 1-foot stump for trees more than 5 inches in diameter.

Tree grade.--A classification of the lower 16 feet of the bole of standing trees based on external characteristics as indicators of the quality and quantity of lumber that could be produced from the tree. Tree grade was assigned to a sample of hardwood sawtimber trees during the 1996 inventory. Also see Log grade.

Tree size class.--A classification of trees based on diameter at breast height, including sawtimber trees, poletimber trees, saplings, and seedlings.

Upper stem portion.--That part of the bole of sawtimber trees above the saw-log top to a minimum top diameter of 4.0 inches d. o. b. or to the point where the central stem breaks into limbs.

Water.--(*a) Bureau of the Census.*--Permanent inland water surfaces, such as lakes, reservoirs, and ponds at least 40 acres in area: and streams, sloughs, estuaries, and canals at least one-eighth of a statute mile wide.

(b) Noncensus.--Permanent inland water surfaces, such as lakes, reservoirs, and ponds from 1 to 39.9 acres in area; and streams, sloughs, estuaries, and canals from 120 feet to one-eighth of a statute mile wide.

Wooded pasture.--Improved pasture with more than 16.7 percent stocking in live trees, but less than 25 percent stocking in growing-stock trees. Area is currently improved for grazing or there is other evidence of grazing.

Wooded strip.--An acre or more of natural continuous forest land that would otherwise meet survey standards for timberland except that it is less than 120 feet wide.

Tables by Property

For all State Forests *(to view the tables below go to www.dnr.gov)*

- Acres of timberland by forest type and property
- Acres of timberland and stand size class and property
- Acres of timberland and stand age class and property
- Acres of timberland and site productivity class and property
- Acres of timberland and site index class and property
- Number of growing stock trees on timberland by species group and property
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- Number of all live trees on timberland by diameter class and property
- Net volume of growing stock on timberland by species group and property
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- Net volume of sawtimber on timberland by species group and property
- Net volume of sawtimber on timberland by forest type and property
- Net volume of sawtimber on timberland by diameter class and property
- All above and belowground biomass on timberland by component and property
- Volume of CWD (coarse woody debris) on forest land by decay class and property
- Volume of CWD (coarse woody debris) on forest land by size class and property
- Vegetative cover on forest land by invasive status and property
- Area of forest land by soil texture and property
- Area of forest land by soil compaction class and property

By State Forest

- Timber acreage by WisCFI forest type and stand size class
    - Coulee Experimental Forest
    - Black River State Forest
    - Brule River State Forest
    - Flambeau River State Forest
    - Governor Knowles State Forest
    - Kettle Moraine State Forest – NU
    - Kettle Moraine State Forest – SU
    - NHAL State Forest
    - Peshtigo River State Forest
    - Point Beach State Forest

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